2010

[IPD/BIM LIGHTING TECH I]

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EXECUTIVE SUMMARY

This document is a composition of requirements for IPD/BIM Existing Conditions modeling and Lighting/Electrical option Technical Assignment I. Through negotiation with instructors, the scope of Technical Assignment this document includes a description of an Existing Conditions Model for the Millennium Science Complex, a discussion of existing room conditions with respect to lighting, existing lighting conditions of spaces, and a report on the state of lighting analysis in BIM programs – specifically Revit MEP.

Lighting/Electrical students from three groups collaborated to compose this document. The existing conditions model is an edited Revit MEP model of the third floor. All teams agreed to use this section of the building due to its wide variety of spaces that appease requirements for the majority of technical assignments and design opportunity. The modeling process for power systems, circuiting, and conduits will be discussed in this section of the report.

Students researched architectural drawings, electrical drawings, schedules, and specifications to compose existing room conditions data and models. The scope of this section includes material finishes, lighting equipment, design criteria, and existing lighting calculation software analysis.

Finally, a discussion on the present state of lighting design in BIM will be presented. This discussion will include topics of user ability to set material properties, input design criteria into spaces, and how Revit MEP calculates an average illuminance for spaces.

Existing Conditions Model

This section discusses processes to provide an "as accurate as possible" fully-functional model of the third floor of the Millennium Science Complex. Topics will include 2D vs. 3D modeling, translating from 2D to 3D, and issues with using platforms such as Revit MEP. The breakdown of subsections includes:

Power System
Circuiting
Conduits

Power System

Existing conditions of the 3rd floor are being modeled in Revit MEP. The primary goal is to have a completely functional MEP model for ease of design changes in the future.

A common problem with non-interconnected modeling systems, such as CAD drafting, is extra work entailed to make changes. Once an item is changed on a sheet, it usually must be changed on several other sheets as well, leaving room for omissions and errors.

For example, in reviewing Bulletin 19 construction documents, it is evident that this problem exists in the Millennium Science Complex project. In this latest revision, several panels have been removed, and it is not clear as to which panels were removed. One-line diagrams, Riser Diagrams, Panel Schedules, and Floor plans all communicate conflicting information. Upon viewing these changes, the contractor must file requests for information and wait for an RFI response – which can be upwards of weeks to respond.

With the proper use of a quality engineering based BIM program, it is possible to avoid such confusion. For instance, if a circuit is edited on a floor plan, the panel schedule will be updated accordingly. If this branch panel is connected to a distribution panel, it will update the feeding panel and so on.

Circuiting

In modeling the existing conditions of the third floor, circuits of receptacles were the first items to be completed. For proper circuiting, the receptacle family must be correct in size, voltage, number of poles, load classification, and apparent load. With these parameters correctly input, the system can be intelligently added to apparent and demand loads on panel schedules.

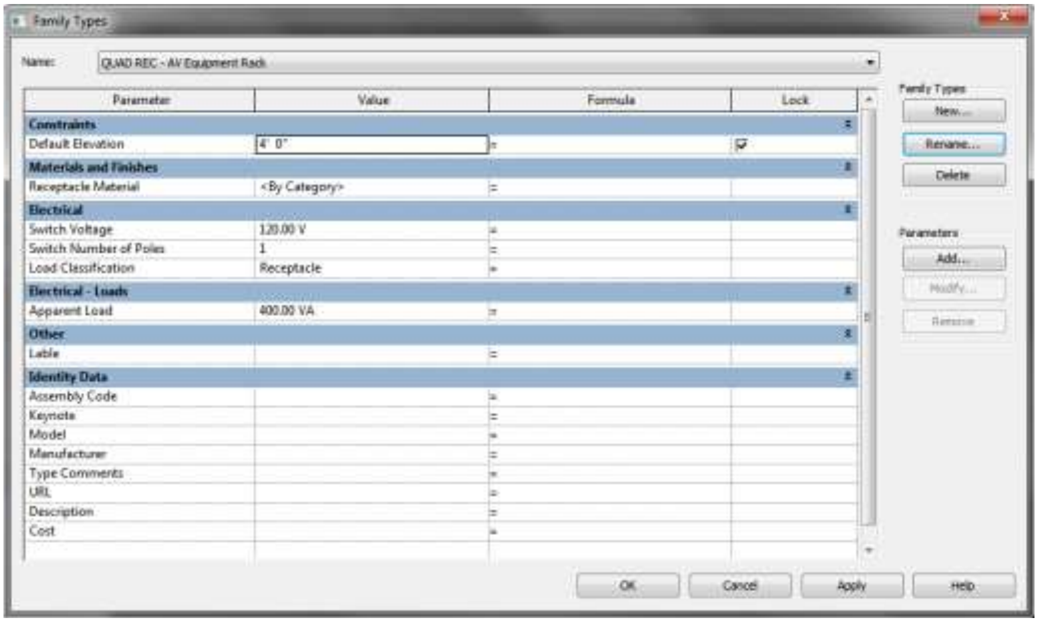

***Figure 1**:* Family Types

Identity data (Figure 1) can be utilized for cost purposes, and even for submittal purposes. If the exact receptacle that will be used is known, a direct web link can be added to a cut sheet of that receptacle. Cost data can be entered, and in doing quantity take-offs, these values can be easily added. Providing Revit MEP models with this information on a large scale to contractors will allow for more accurate bidding in the future, saving the owner more money that could be lost in change orders.

Now that the receptacle in Figure 1 above has been edited to a quad receptacle using 400VA on 120V, the next step is to add that receptacle to a circuit.

The example in Figure 2 is a pre-built furniture system that requires receptacles and data outlets to be installed and wired. Four receptacles and data outlets per post in the furniture were called for in the design.

***Figure 2**: Assigning Receptacles*

The question marks indicate the receptacles have not yet been assigned to a circuit yet (Figure 2). It's an annotative tag that is automatically placed into the receptacle family that will be updated with the panel name and circuit number. These receptacles are to be circuited to panel LR-3C2, a 42-pole 208Y/120V panel.

LR-3C2 is shown here, it has already been set up according to the parameters obtained from the current drawings (Figure 3).

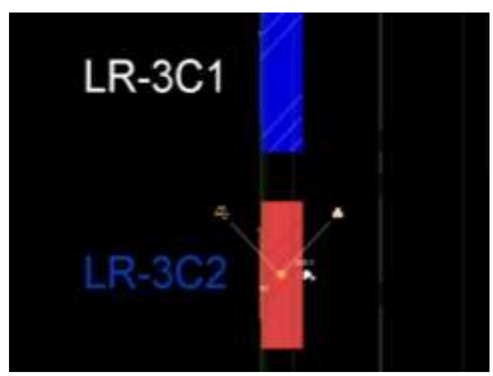

***Figure 3**:* Panel LR-3C2

Next, selecting the appropriate receptacles and clicking the power button will allow them to be connected to a panel (Figure 4).

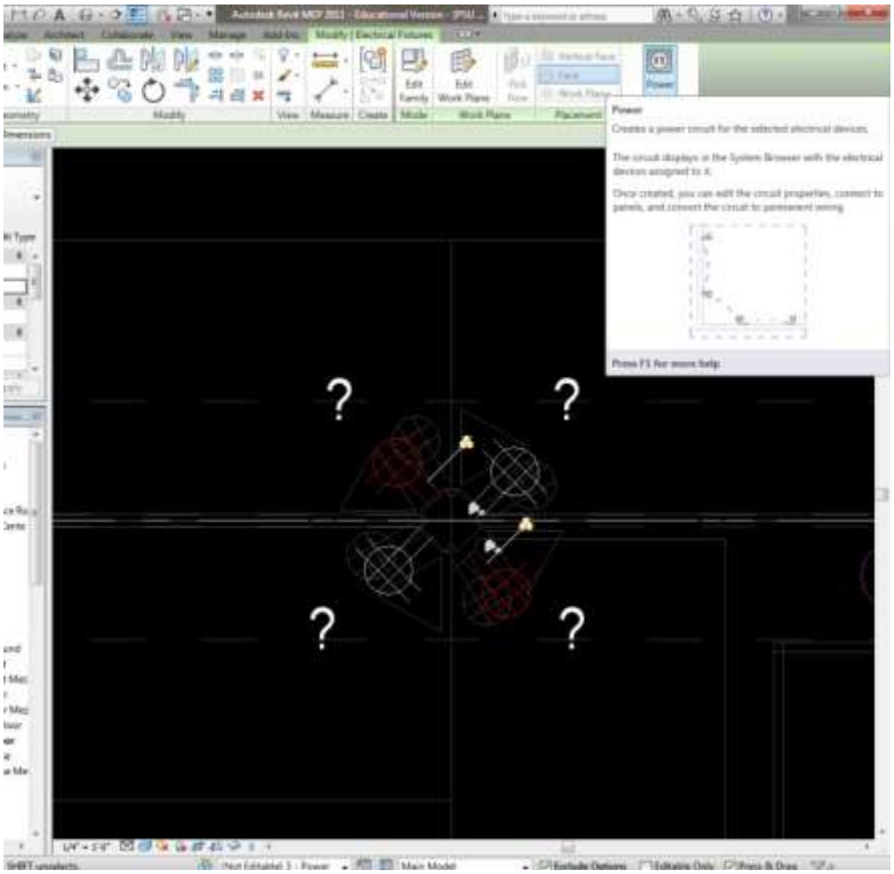

Figure 4: Powering the circuit.

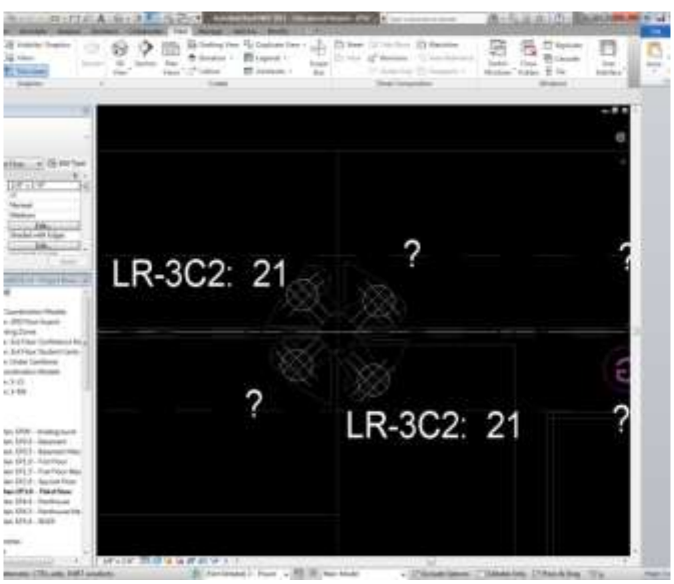

Figure 5: Updated annotation tags.

After selecting the panel LR-3C2, the annotation tags will automatically update, showing the designer the connected panel and circuit number. These tags can be edited to look like a CAD standard format appropriate for the design firm. This tag was edited to be "PANEL NAME: CIRCUIT NUMBER" (Figure 5).

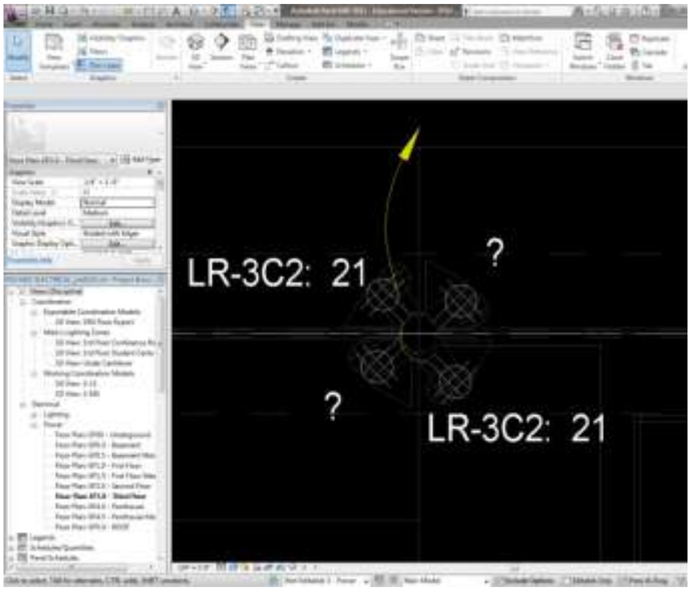

***Figure 6**:* Home run technique.

The home run technique (Figure 6) can be easily utilized with the touch of a button as well. Although, Revit MEP will not automatically place tick marks on the wires, it is an available tool.

The circuit was automatically named "P.C. recept Neurophys Invitro W-321." This was a parameter of the receptacle edited to read "RECEPTACLE TYPE; ROOM NAME; ROOM NUMBER" for ease of reference (Figure 7). The circuit was placed on the first available space in the panel board, which happens to be circuit #21.

***Figure 7**:* Receptacle naming.

Moving the circuit with the "move up/down/left/right" commands places in its appropriate place on #30. Since the circuit was moved from Phase B to Phase C, the schedule adds loads automatically, such as a spread sheet would on typical electrical design jobs (Figure 8).

***Figure 8**:* Moving circuits on the panel board.

Another improvement for electrical systems in RevitMEP 2011 is the ability to customize a panel schedule to look the way the user would like. The panel schedule shown in Figure 8 has been customized to be formatted for construction documents.

Conduits

For coordination purposes, the Millennium Science Complex requires each contractor to create a BIM coordination model. The electrical contractors were to draw feeder conduits and panels. They were able to provide the IPD/BIM teams with current AutoCAD MEP models of their work to date. These conduits are being modeled in the RevitMEP model for our own coordination purposes by using the contractor's models as a reference for locations and conduit sizes.

Drawing conduit in RevitMEP allows the user to create schedules for quantity take-offs, once again, allowing for much more accurate bidding.

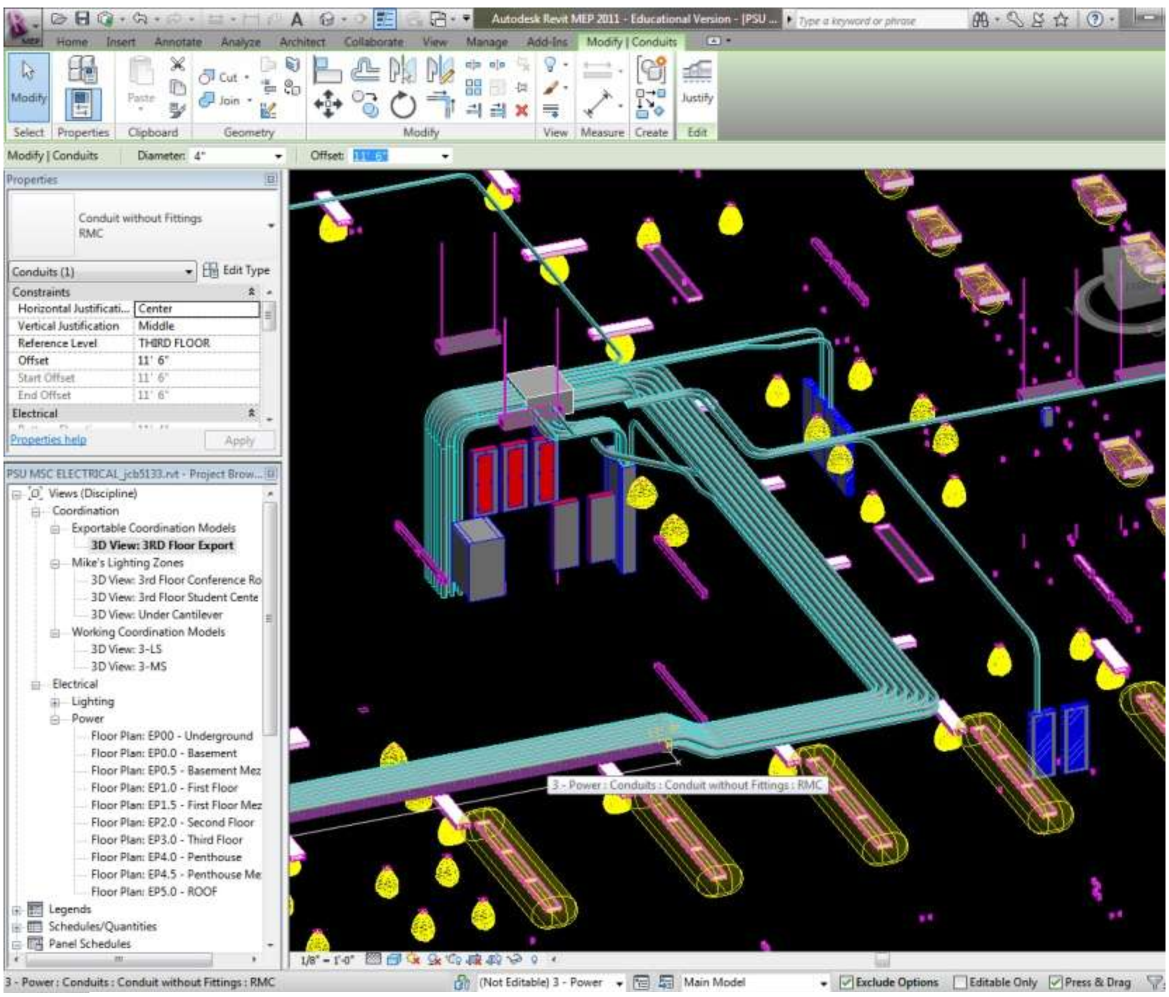

Figure 9: RevitMEP electrical model.

The image above (Figure 9) shows the electrical components of the RevitMEP model (current as of 9.29.2010). The conduits shown are located in the third floor electrical room of the Material Science wing. The majority of these conduits are four inch feeders that go either to or from the penthouse. This area was a substantial problem area for the coordination team on-site. Once a Navisworks model is imported, clash detection can be utilized to help coordinate where duct work and electrical equipment may interfere with each other.

Conduits in RevitMEP are not able to "carry" conductors in them. If this issue were to be resolved in later versions of the program, voltage drop calculations and wire lengths can be far more accurate. Currently, RevitMEP uses an X,Y coordinate system to determine a voltage drop calculation. It assumes the wire length to be as follows:

$$\text{Voltage Drop Length} = (X_{panel}-X_{closest\ electrical\ equipmet})+(Y_{panel}-Y_{closest\ electrical\ equipmet})$$

This process essentially adds the shorter sides of a triangle. On a positive note, it does not include the hypotenuse, allowing the voltage drop calculation to not take the shortest distance the wire could travel. This means the calculation operates closer to a worst-case-scenario for conductor routing length. It has not been determined if the voltage drop calculation includes the Z-coordinate. It is not a 100% accurate calculation at this point in time, but a good place to start for an initial design calculation.

Room Existing Conditions and Design Criteria

The following section consists of three spaces and their existing conditions: a third floor seminar room, third floor café/lounge area, and the third floor corridor/study area. The items discussed are similar to Technical Assignment I for Lighting/Electrical thesis students.

Seminar Rooms

Seminar rooms are generally complicated spaces to design. Their use ranges from face-to-face meetings to video teleconferencing. With the spectrum of casual to difficult visual tasks in the space, at least two lighting systems should be used. According to the IESNA Lighting Handbook, the systems should be considered to include the following:

1. A general lighting system in which the control of the illuminance is provided by switches or dimmers.
2. A supplementary lighting system consisting of down lighting with dimmer control for slide projection and other low-level illumination requirements.
3. A perimeter or wall-washing lighting system controlled with dimmers for better visual appeal and for wall mounted presentations.

Video conferencing will also take place in the seminar rooms in the Millennium Science complex. This task is challenging to design due to the dual nature of the lighting system's responsibility. Adequate light is required for tasks performed by occupants different light is required for illuminating the occupants enough for far end users to model faces. Occupants should not be forced into feeling as if on stage for the camera. The existing equipment and design criteria are as follows:

Fixture Type	Description
DC-1	Kurt Versen Lighting #H8643-SW-WT; 32W Triple Tube CFL; 6"x6" square open aperture ceiling recessed CFL down light; Supplied with integral electronic ballast with specified ballast factor or higher; Ballast Factor = 0.98; Operating Voltage = 277V
DC-1A	Same as DC-1; Substitute the lamp with a 42W Triple Tube CFL
DC-4-d1	Cooper Lighting #C6142-6181-LI-1G-WF; 42W Triple Tube CFL; 6" round aperture lensed CFL down light with 10% dimming ballast; Advance Mark 7 Series Ballast with ballast factor = 1.0; Operating Voltage = 277V
NF-1B-d1	Ledalite #9814-D1-CR&ST-T232-S-(WIRING)-2; (2) 32W T8 Fluorescent Lamps; 1x4 Ceiling recessed fluorescent down lights with 10% dimming ballast; Advance Mark 7 Series Ballast with ballast factor = 1.0; Operating Voltage = 277V

Table 1*:* Seminar Room Lighting Hardware.

Surface	Mark/Material	Notes
East Wall	Painted GWB – Benjamin Moore OC-26 Silver Satin, eggshell Acoustic Wall Panel – Novawall 2" Panel, Classic	Specification 09900 Specification 09900
West Wall	Acoustic Wall Panel – Novawall 2" Panel, Classic	Specification 09900
North Wall	Painted GWB – Benjamin Moore OC-26 Silver Satin, eggshell Polyvision 10' Markerboard – 2' tack, 6' marker, 2' tack; 555 Series	Specification 09900
South Wall	Painted GWB – Benjamin Moore OC-26 Silver Satin, eggshell Folding partition with Maharam Nano Point 901410 Mega Nano cover in 003 Silver	Specification 09900
Doors	<2> – Wood veneer – natural maple, small view pane <3> – Wood veneer- natural maple, large view pane	<2> – GL-10, GL-11, GL-12 glazing <3> – GL-10 glazing
Ceiling	Armstrong ACT Ultima HRC Beveled Tegular Painted GWB – Benjamin Moore I-04 White, eggshell	Specification 09500 Specification 09900
Floor	J&J Commercial/Invision Flax Modular 913 Kona Carpet	Specification 09685
Glazing	GL-10 – Clear float glass, fully tempered, 1/4" Class 1 Clear GL-11 – FireLite Plus fire-rated glazing by Nippon Electric Glass, 5/16" overall, τ_v = 0.85, ρ_v = 0.09 GL-12 – Laminated safety glass, 1/2"	Specification 08800

***Note:** Seminar rooms are dividable and thus are mirror of each other.*

Table 2*:* Seminar Room Room Finishes

IESNA Design Criteria

Several considerations of high priority must be addressed when designing seminar rooms relative to both meeting tasks and video conference tasks:

Meeting Tasks	Illuminance
Appearance of space and luminaires	30 fc Horizontal
Direct glare avoidance	5 fc Vertical
Modeling of faces	

Video Conferencing	Illuminance
Direct glare avoidance	50 fc Horizontal
Modeling of faces	30 fc Vertical
Source-Task-Eye geometry	

Visual Display Terminals (VDT)	Illuminance
	3 fc Horizontal
	3 fc Vertical

Luminance Ratios

- Paper – VDT: 3:1 / 1:3
- Task – Surroundings (adjacent): 3:1 / 1:3
- Task – Remote Surface: 10:1 / 1:10

Meeting tasks have a variety of ulterior uses. When out-of-town personnel enter the room, it must be representative of the class and professionalism that Penn State is known for. Uniformity of lighting zones and the ability to recognize that multiple scene selections are available contribute to dictating that the room is ready for any activity that may use the space. When general meetings are performed, it is imperative that occupants are comfortable and able to give full attention to the presenter or speaking person in the meeting. Avoiding direct glare can be achieved with uniform overhead lighting with spacing of luminaires out of geometry range for reflection off of tables.

Other considerations stem from the multiple uses of these seminar rooms. The use of a mobile divider adds complexity to the luminaire layout. When the wall is collapsed, the two room layouts must be uniform as one large room. When the wall is dividing the space, each room must appear to be its own entity. This duality is achieved by mirroring one room across the dividing wall. Schemes can be addressed for specific tasks in the divided rooms also. Task specific down lights deliver vertical illumination to walls with marker boards and the divider wall. The overhead lighting is on dimmable ballasts able to reach ten percent output, which allows for reduced glare in teleconferencing and computer work.

ASHRAE 90.1-2007

All spaces in the Millennium Science Complex will be assumed using the space-by-space method in ASHRAE 90.1, Table 9.6.1. Lighting Power Density for the seminar space is assumed to fall under the following class:

Conference/Meeting/Multi-Purpose: 1.3 W/ft^2

Applicable Drawings

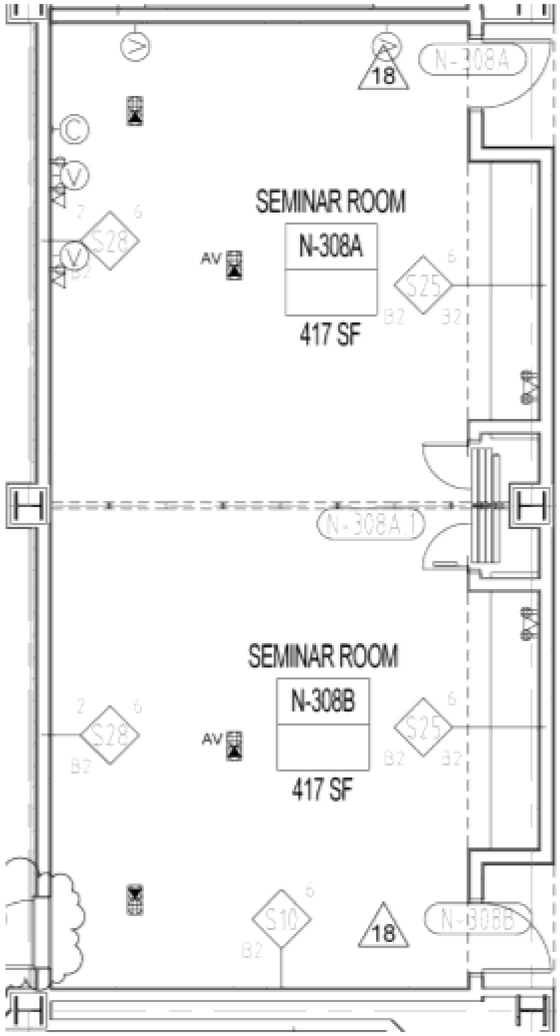

***Figure 10**:* Seminar Rooms Floor Plan.

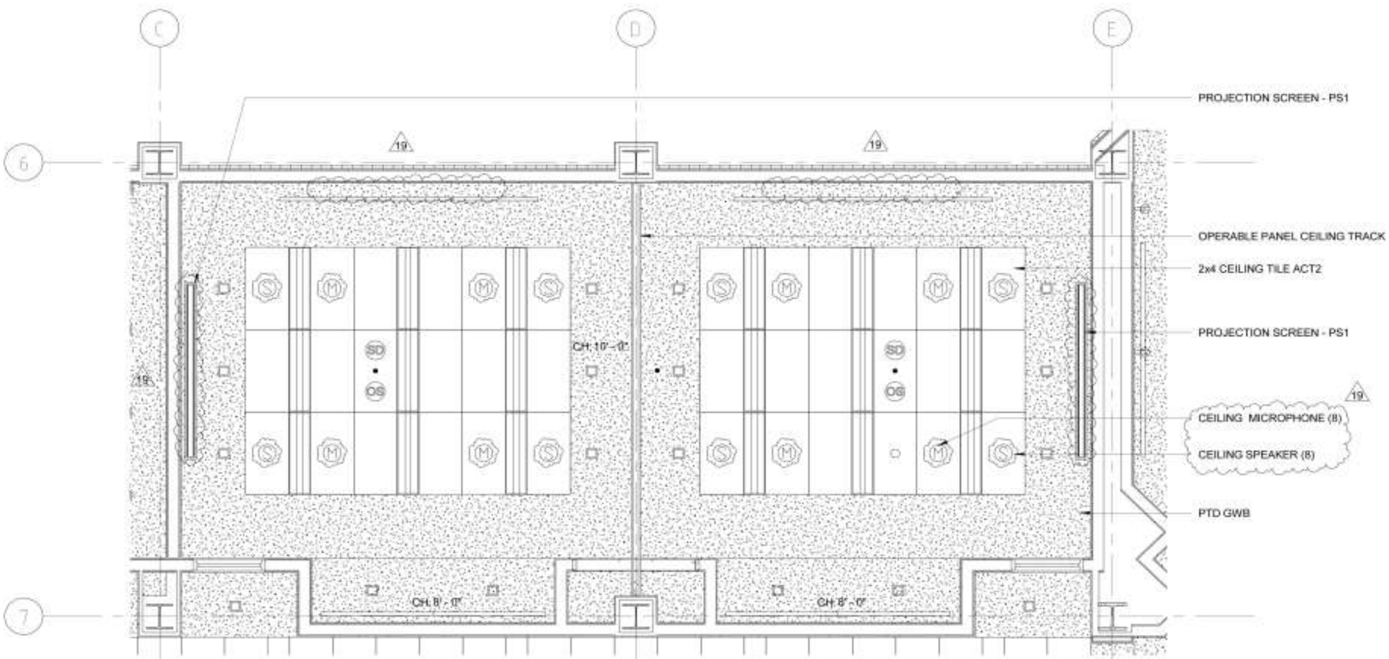

***Figure 11**: Seminar Rooms Reflected Ceiling Plan.*

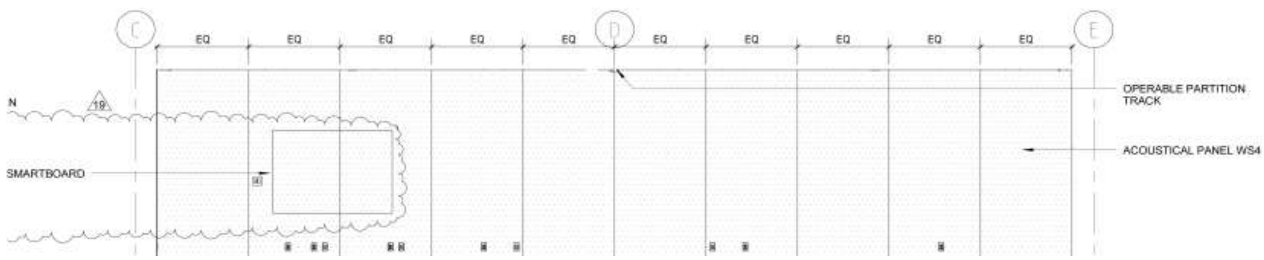

***Figure 12**: Seminar Rooms South Elevation.*

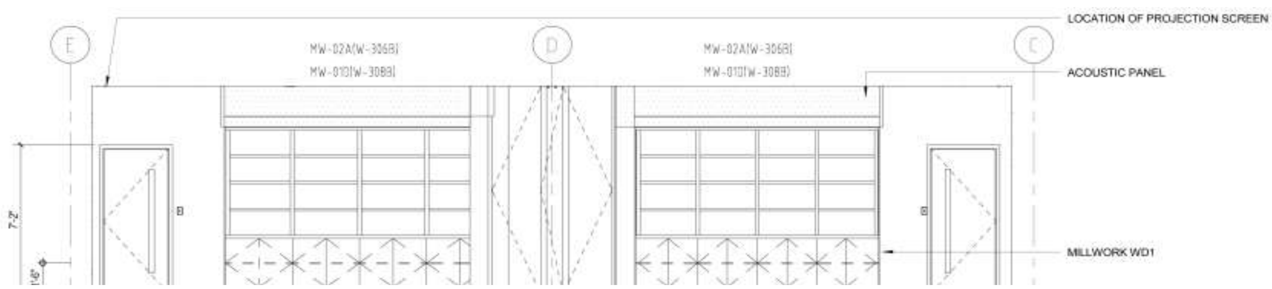

***Figure 13**: Seminar Rooms North Elevation.*

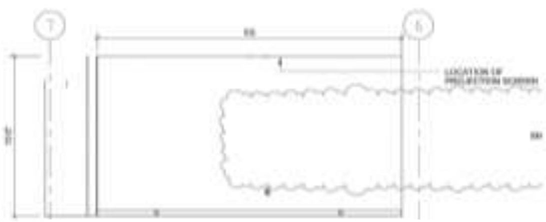

***Figure 14**: Seminar Rooms West*

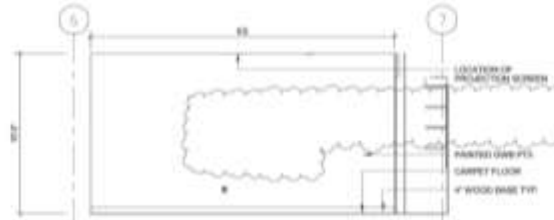

***Figure 15**: Seminar Rooms East*

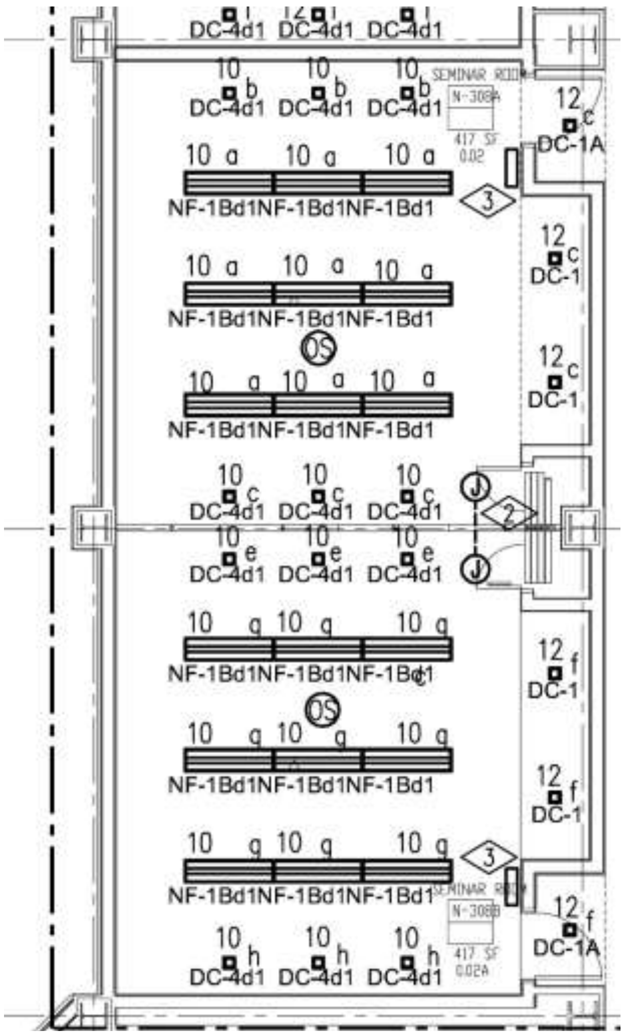

***Figure 16**: Seminar Rooms Lighting Plan*

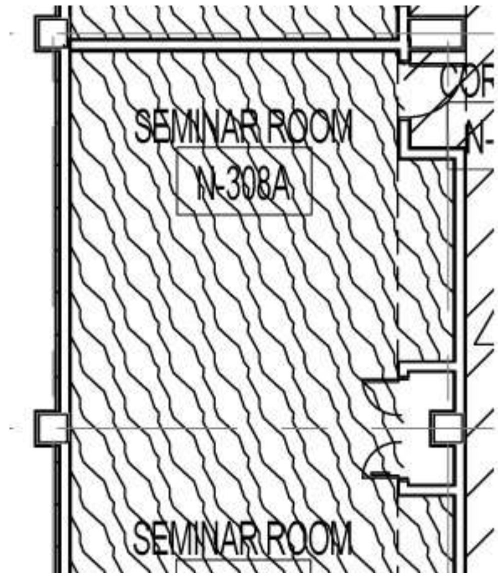

***Figure 17**: Seminar Rooms Finish Floor*

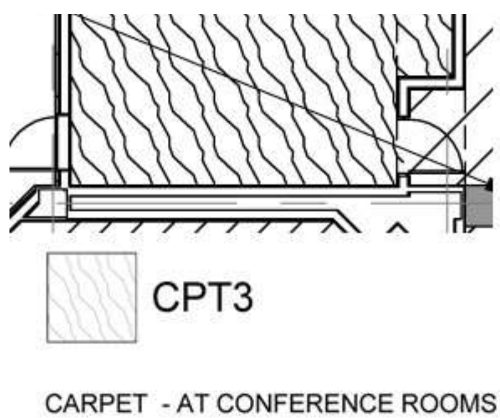

***Figure 17**: Seminar Rooms Floor Finish Plan*

Café/Commons

The commons space within the Millennium Science Complex has several uses. First, it is an eating space and must render food and colors appropriately. Secondly, it is part of pedestrian traffic between the two wings of the building and must guide occupants as such. Thirdly, it is a gathering space for less formal meetings and must be dynamic in nature. Materials in the café are relatively uniform, just as the rest of the building. Existing equipment and design criteria are as follows:

Fixture Type	Description
DC-1A	Kurt Versen Lighting #H8643-SW-WT; 42W Triple Tube CFL; 6"x6" square open aperture ceiling recessed CFL down light; Supplied with integral electronic ballast with specified ballast factor or higher; Ballast Factor = 0.98; Operating Voltage = 277V
EL-5	Concealite #F5-REM-75-277VAC; (2) 75W Quartz Halogen GU-10 bi-pin; Ceiling concealed retractable emergency lighting fixture; Lamps rotate out and switch on upon activation; Operating Voltage = 277V
NF-5	SE'LUX M100 Staggered #M1R1S-2T8-OD-(Mounting)-(Length)-WH-277; (2) T8 Fluorescent lamps; Recessed linear fluorescent slot lights with lens; Ballast Factor = 0.88; Operating Voltage = 277V
NF-5-d1	NF-5 with specified dimming ballast
NF-10	Ledalite #3808-t02-E-N-(Length)-1-277-E-W; (2) T8 Fluorescent lamps; Shelf top surface mounted asymmetrical ceiling washer linear fluorescent fixture; Ballast Factor = 0.88; Operating Voltage = 277V

Table 3: Café/Commons Lighting Hardware

Surface	Mark/Material	Notes
East Wall	Painted GWB – Benjamin Moore OC-26 Silver Satin, eggshell	Specification 09900
West Wall	Painted GWB – Benjamin Moore OC-26 Silver Satin, eggshell	Specification 09900
North Wall	Painted GWB – Benjamin Moore OC-26 Silver Satin, eggshell Painted GWB – Benjamin Moore color to match ICI/Dulux #53YR 17/504 Orange, Copper ORD#A0425 satin finish	Specification 09900 Specification 09900
South Wall	Painted GWB – Benjamin Moore OC-26 Silver Satin, eggshell	Specification 09900
Ceiling	Armstrong ACT Ultima HRC Beveled Tegular	Specification 09500
Floor	TM Supply TM#08-2381; 3/8" thick, thin set poured epoxy terrazzo with 4" integral coved wall base	Specification 09440
Glazing	GL-1 and GL-2 – 1/4" outer glass, 1/2" air space, 1/4" inner glass; Viracon VE1-2EM Low-e coating on #2 unit within the assembly VLT = 0.70 R_{out} = 0.11 U_{winter} = 0.29 U_{summer} = 0.26 SC = 0.44 SHGC = 0.38 LSG = 1.85	Specification 08800

Table 4: Café/Commons Room Finishes

IESNA Design Criteria

Several considerations of high priority are addressed when designing for food service spaces:

Food Courts	Illuminance
Appearance of space and luminaires	30 fc Horizontal
Color Appearance and Contrast	3 fc Vertical
Daylighting and Daylight Control	
Dining	Illuminance
	10 fc Horizontal
	3 fc Vertical
Food Displays	Illuminance
	50 fc Horizontal

Being such a large space, occupants may become dissatisfied or uncomfortable with a non-uniform layout of luminaires or performance when attempting a variety of tasks. The space must be flexible enough to hold large social gatherings without tables and be able to have tables for normal space operation. Uniformity is achieved through rows of recessed linear fluorescent luminaires over the largest gathering space to provide a blanket of light to the space below. This uniformity will allow for multiple activities to be performed by occupants – eating, reading, laptop computer work, etc. Luminaires close to the large viewing window are wired to ten percent output dimming ballasts to adjust for the presence of daylight in the space. The available daylight will mostly be in the morning hours as the window wall is facing nearly due east. Four video screens (or video walls as noted) are mounted on each of the north and south walls. As the fixtures in the open space are direct distribution, these media areas should be outside of the distribution of the recessed luminaires to avoid glare.

Color rendering will also be a large consideration in this space. The two activities taking place in this space rely heavily on color – socializing and eating. Occupants do not want to look at others and see discoloration in faces, possibly causing the other occupant to look ill. Food preparation and consumption will also be happening in the space. Food needs to be appropriately rendered, not only for the consumer, but also for staff to be able to visually affirm quality of food.

ASHRAE 90.1-2007

Lighting Power Density for the café and Commons space is assumed to fall under one of the following classes:

Dining Area:	0.9 W/ft^2
Food Preparation:	1.2 W/ft^2

Applicable Drawings

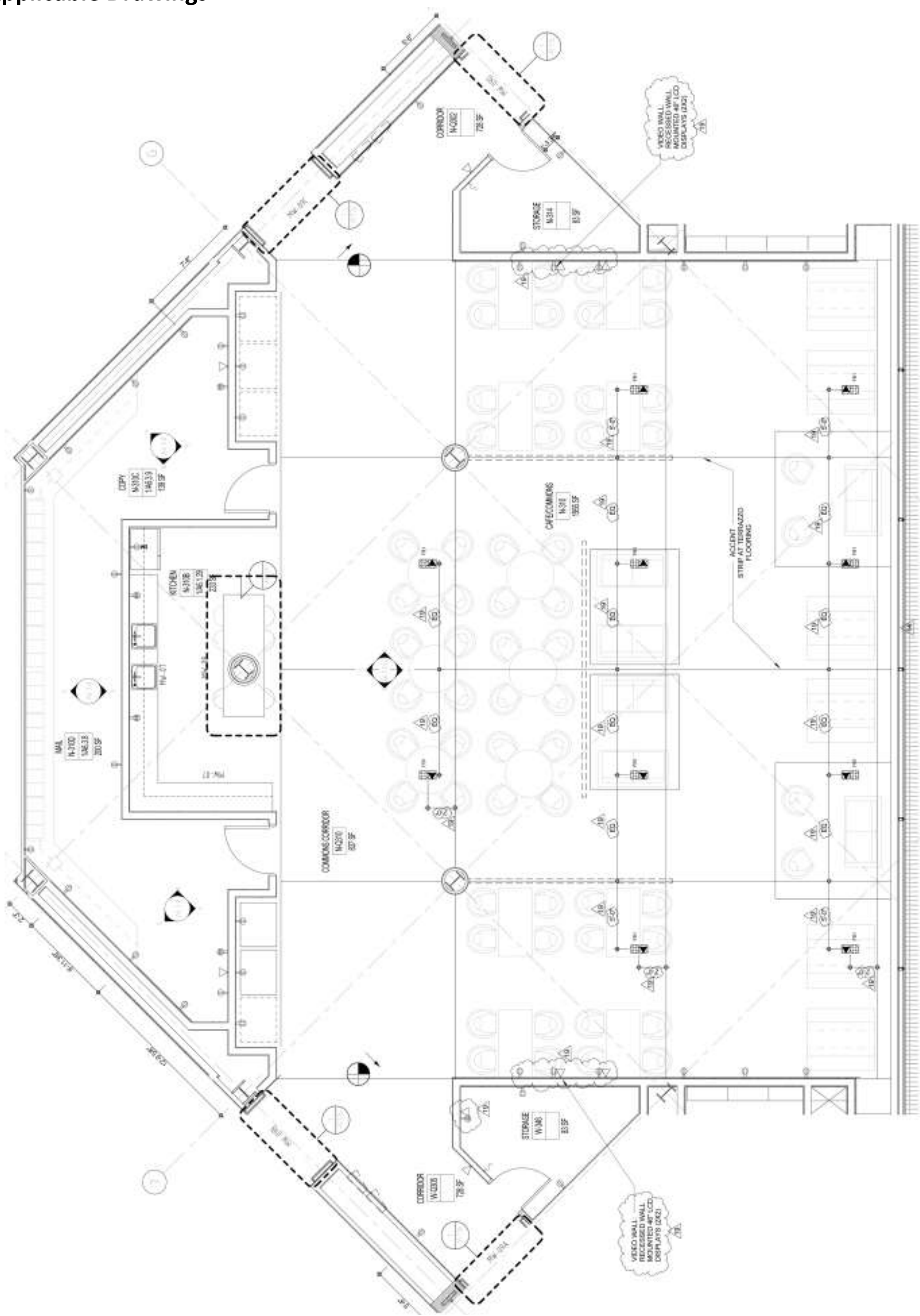

***Figure 18**:* Café/Commons Floor Plan.

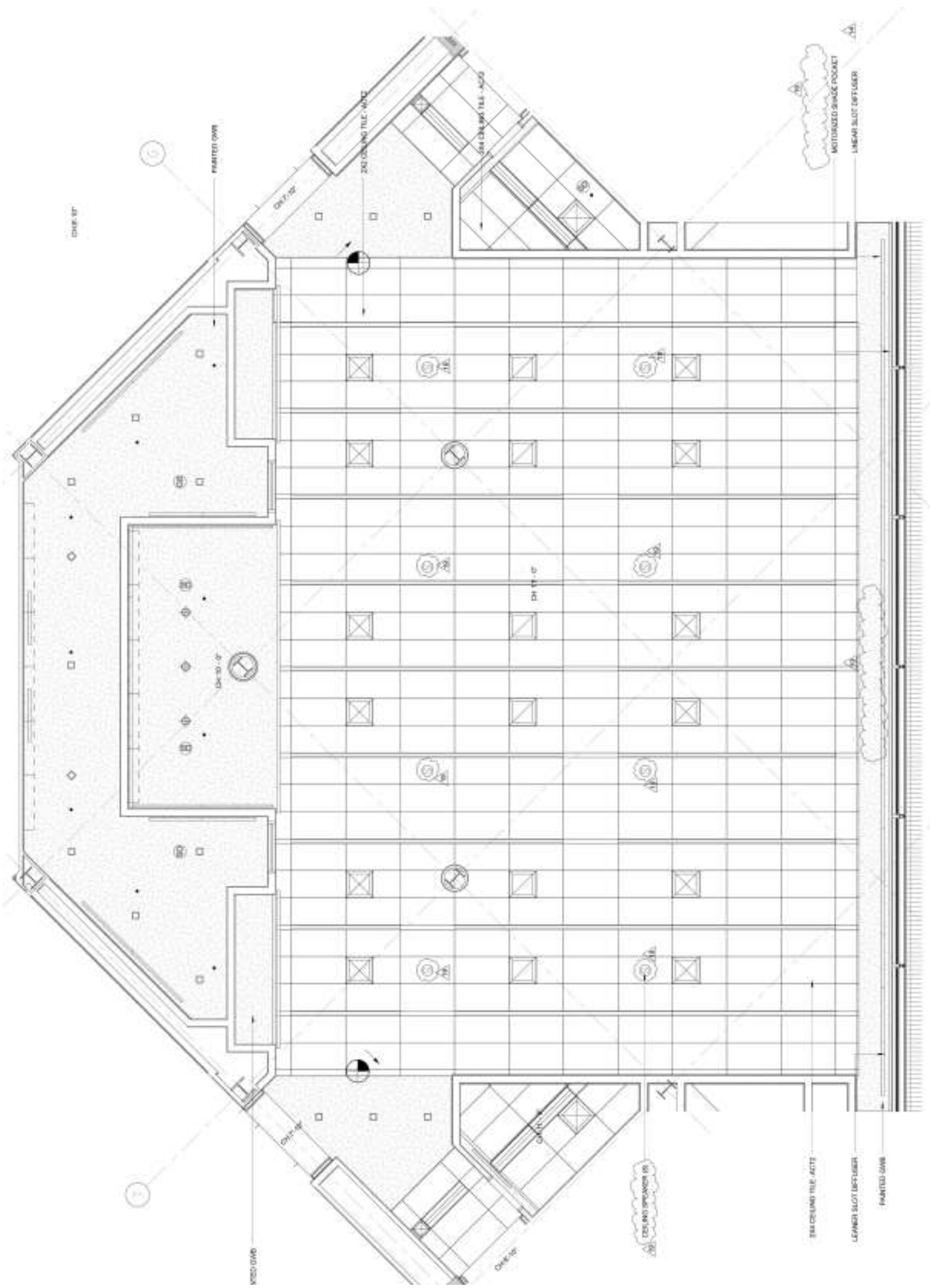

***Figure 19**: Café/Commons Reflected Ceiling Plan.*

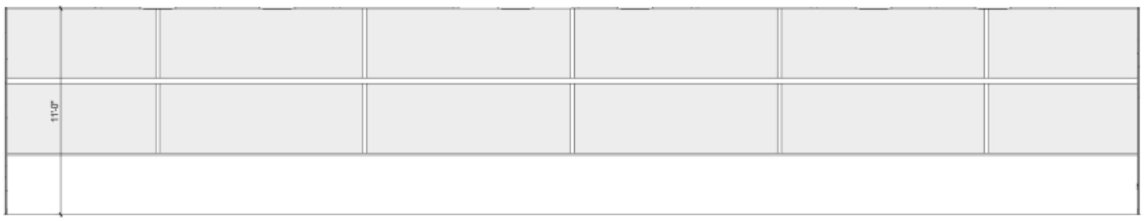

***Figure 20**:* Café/Commons South Elevation.

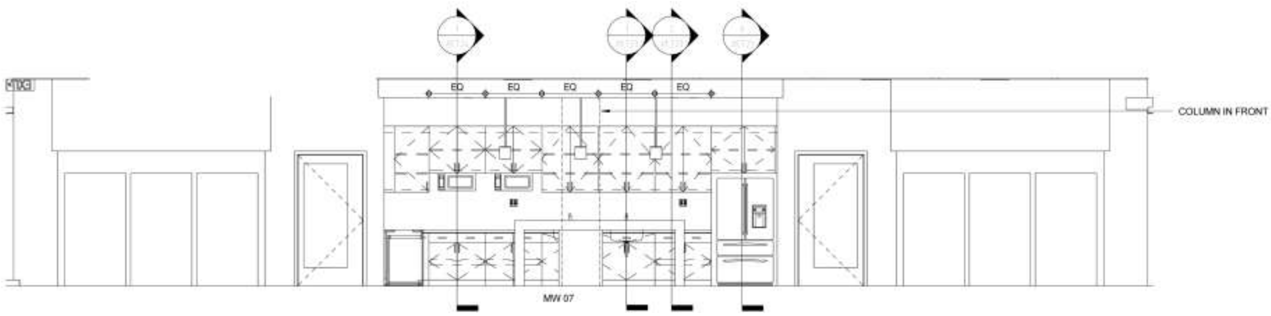

***Figure 21**:* Café/Commons North Elevation.

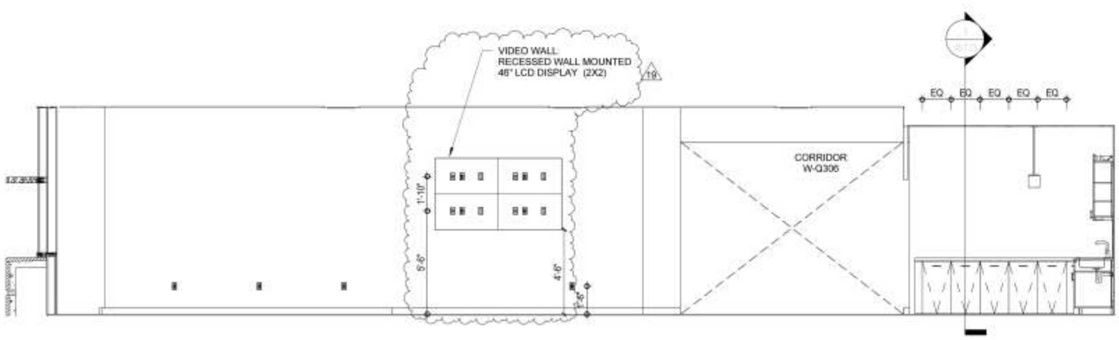

***Figure 22**:* Café/Commons West Elevation.

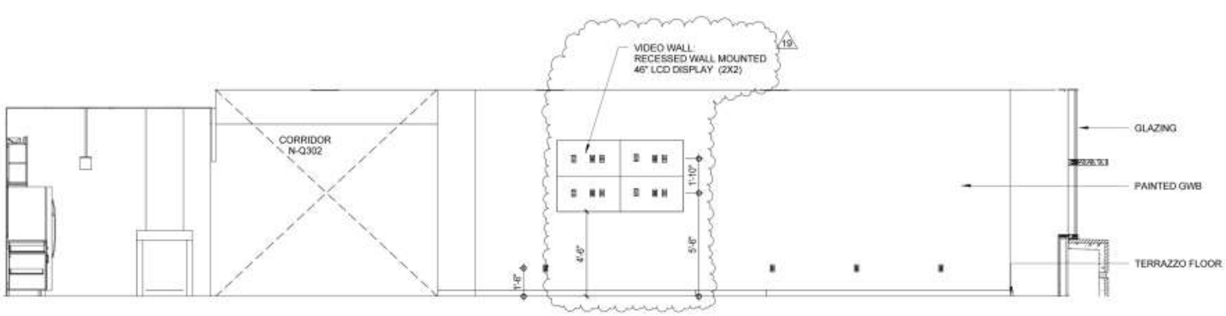

***Figure 23**:* Café/Commons East Elevation.

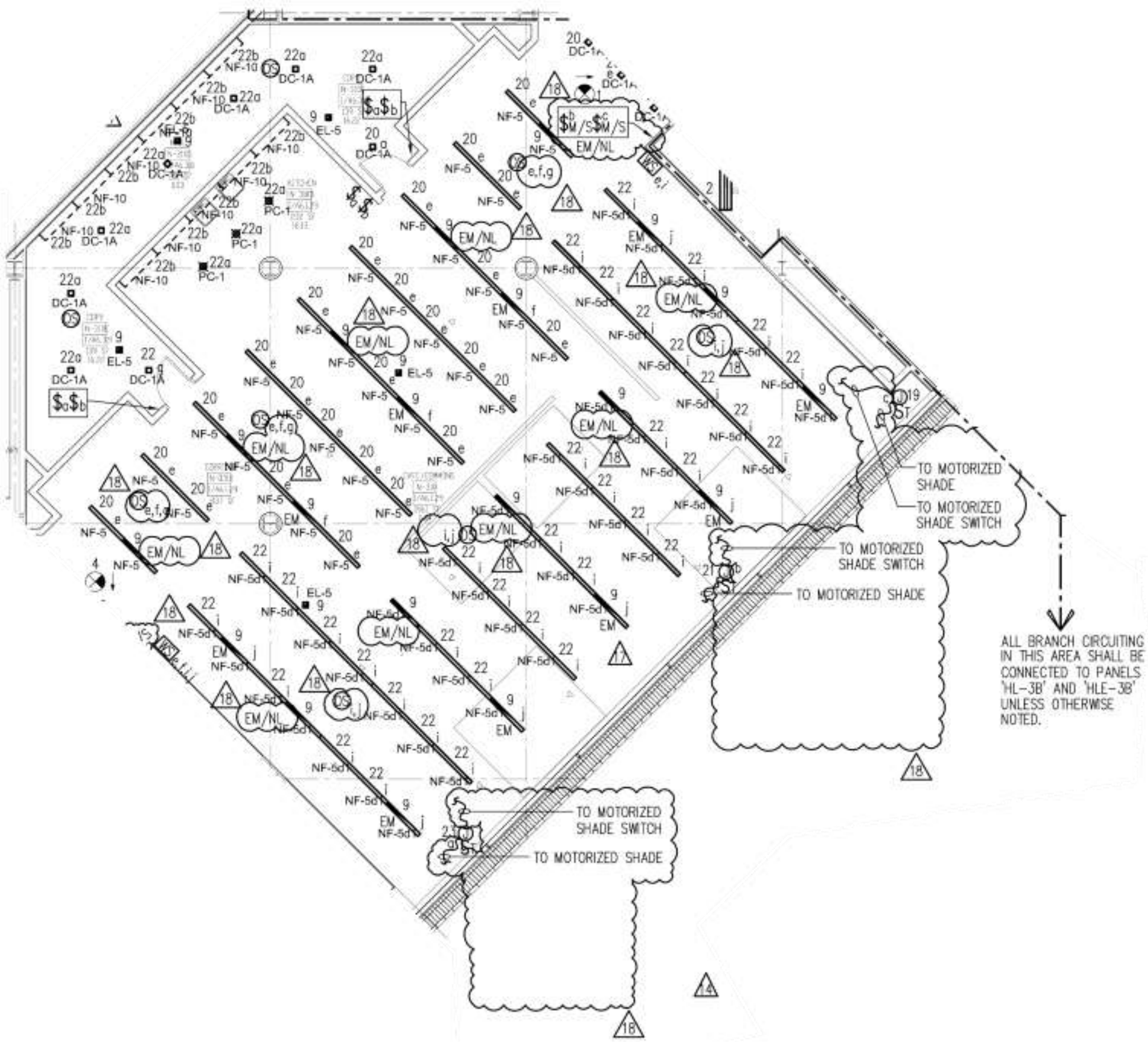

***Figure 24**:* Café/Commons Lighting Plan.

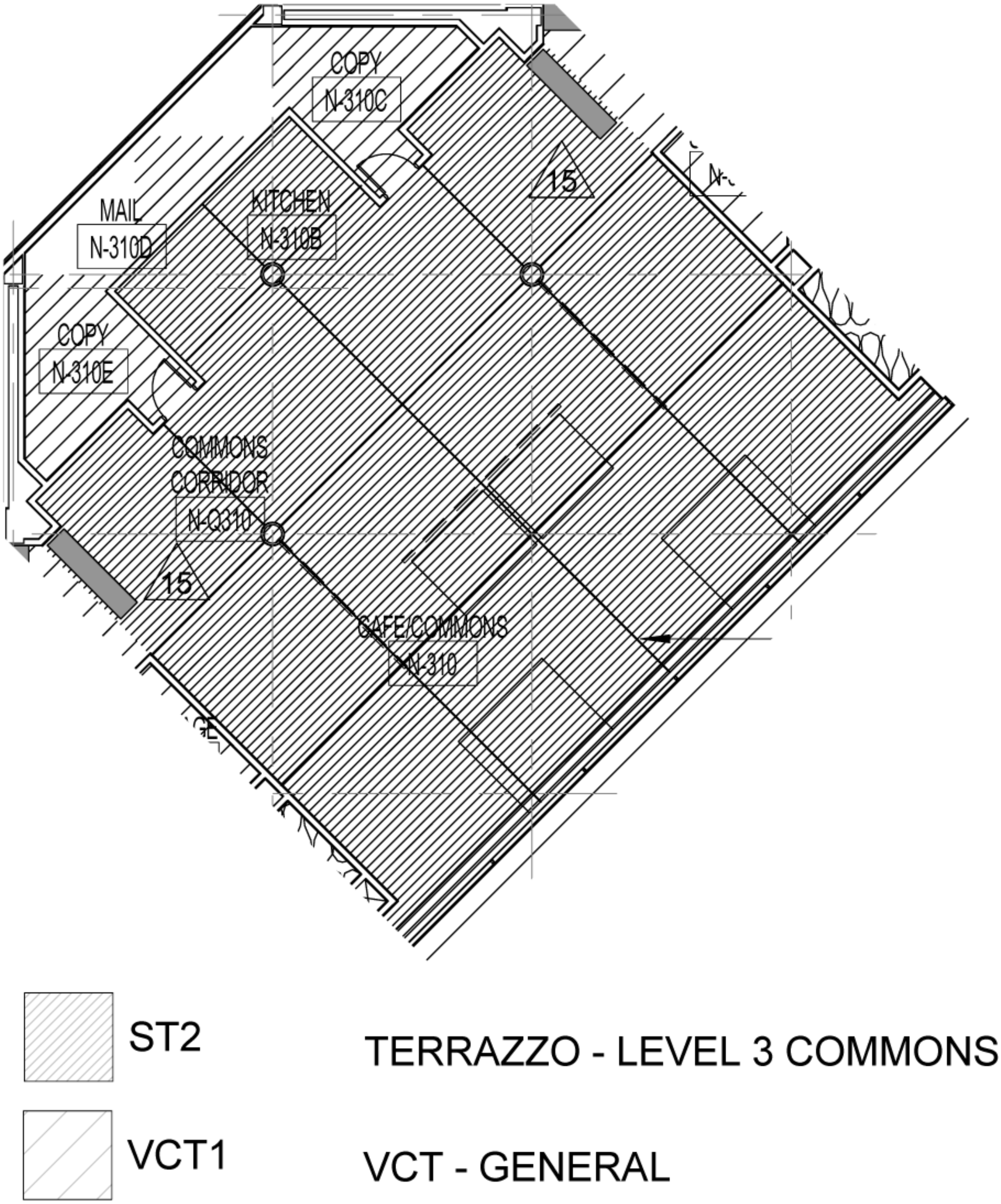

Figure 25: Café/Commons Finish Floor Plan.

Corridor/Study Areas

Corridor and Student Study areas present a unique situation for lighting. The student study areas are open to the corridor which poses an illuminance paradox for the designer. Light delivered to the study areas will also be falling on the floor of the corridor, thus possibly creating sections of high illuminance at study areas followed by sections of low illuminance near offices. Existing equipment and design criteria are as follows:

Fixture Type	Description
NF-1	Ledalite #9814-D1-CR&ST-T232-S-(WIRING)-2-(Ballast); (2) 32W T8 Fluorescent Lamps; 1x4 Ceiling recessed fluorescent down lights; Ballast factor = 0.88; Operating Voltage = 277V
NF-1B-d1	Ledalite #9814-D1-CR&ST-T232-S-(WIRING)-2; (2) 32W T8 Fluorescent Lamps; 1x4 Ceiling recessed fluorescent down lights with 10% dimming ballast; Advance Mark 7 Series Ballast with ballast factor = 1.0; Operating Voltage = 277V

***Table 5**:* Corridor/Study Areas Lighting Hardware

Surface	Mark/Material	Notes
East Wall	Painted GWB – Benjamin Moore OC-26 Silver Satin, eggshell	Specification 09900
West Wall	Painted GWB – Benjamin Moore OC-26 Silver Satin, eggshell	Specification 09900
North Wall	Painted GWB – Benjamin Moore 2111-60 Barren Plain, eggshell (Student Study & Corridor) Painted GWB – Benjamin Moore 2029-40 Stem Green, eggshell (Lounge)	Specification 09900
South Wall	Painted GWB – Benjamin Moore OC-26 Silver Satin, eggshell	Specification 09900
Ceiling	Armstrong ACT Ultima HRC Beveled Tegular	Specification 09500
Floor	Mannington Solidpoint Vinyl Composition Tile 12”x12” in 341 Cameo White (Corridor) J&J Commercial/Invision Altered Elements Weathered Steel Modular 333 Iron Carpet (Student Study) J&J Commercial/Invision Flax Modular 913 Kona Carpet (Lounge)	Specification 09685 Specification 09685
Glazing	GL-1 and GL-2 – 1/4” outer glass, 1/2” air space, 1/4” inner glass; Viracon VE1-2EM Low-e coating on #2 unit within the assembly VLT = 0.70 R_{out} = 0.11 U_{winter} = 0.29 U_{summer} = 0.26 SC = 0.44 SHGC = 0.38 LSG = 1.85	Specification 08800

***Table 6**:* Corridor/Study Areas Room Finishes

IESNA Design Criteria
Considerations of high priority with respect to the study area, use of VDT screens in the study area, and the corridor:

Corridors	Illuminance
Shadow Avoidance	5 fc Horizontal
Study Areas (Reading Tasks)	Illuminance
#2 Pencil Tasks	30 – 50 fc Horizontal
Printed Tasks	
Points of Interest	
Avoid Reflected Glare	
Avoid Shadows	
VDT Screens	Illuminance
Avoid Reflected Glare	3 fc Horizontal
Avoid Direct Glare	3 fc Vertical
Luminance of Room Surfaces	
Source/Task/Eye Geometry	
Luminance Ratios	
Paper – VDT: 3:1 / 1:3	
Task – Adjacent Surroundings: 3:1 / 1:3	
Task – Remote Surfaces: 10:1 / 1:10	

Corridors and study areas individually are relatively straight forward to design, but when they are coupled without a barrier, the design is more complicated. Corridor spaces only require five footcandles of illuminance, yet in this application they are adjacent to study spaces requiring thirty to fifty footcandles for various tasks. Light falling on the corridor from the study areas will easily meet this illuminance. As discussed at the beginning of this topic, the study areas may unintentionally provide areas of high illuminance in the corridor. Orienting the luminaire perpendicular to the corridor path will help dissolve some of the spill into the corridor from the study areas.

Daylight integration is seen in the study areas as all luminaires are wired to dimming ballasts down to ten percent outputs. Large challenges in controlling light in the study areas still exist in the form of recommended vertical illuminance values. The corridor and study areas are oriented towards the solar south east. Low level sun angles in the morning and early afternoon may pose problems for students working at the computers in this area.

ASRAE 90.1-2007
Lighting Power Density for the café and lounge space is assumed to fall under one of the following classes:

Study Area:	1.2 W/ft^2
Corridor:	0.5 W/ft^2

*The study area is assumed to be a “Lounge/Recreational” space by ASHRAE 90.1 definition.

Applicable Drawings

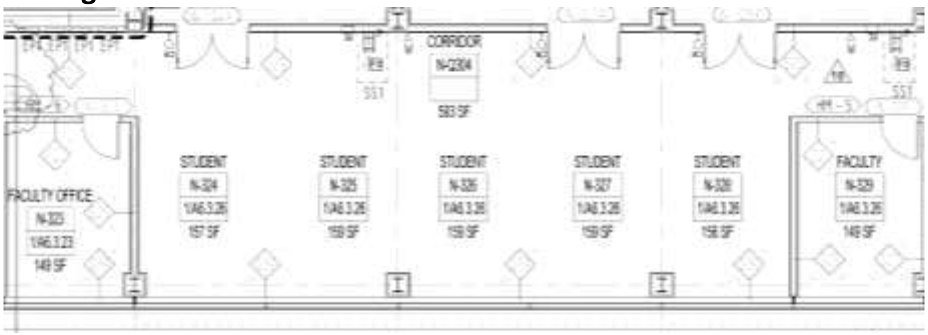

***Figure 26**:* Corridor/Study Area Floor Plan.

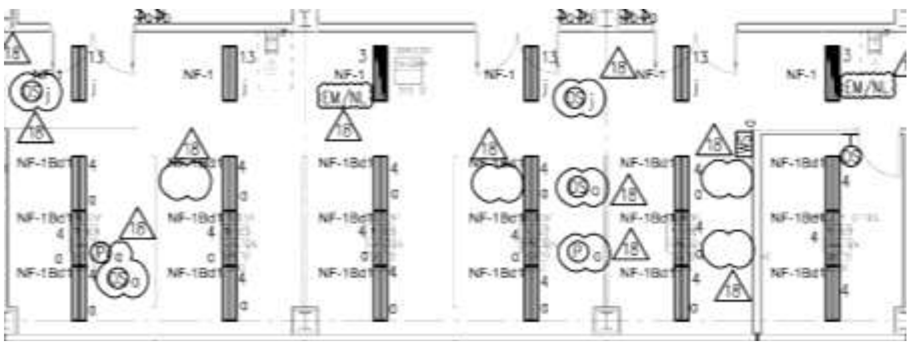

***Figure 27**:* Corridor/Study Area Lighting Plan.

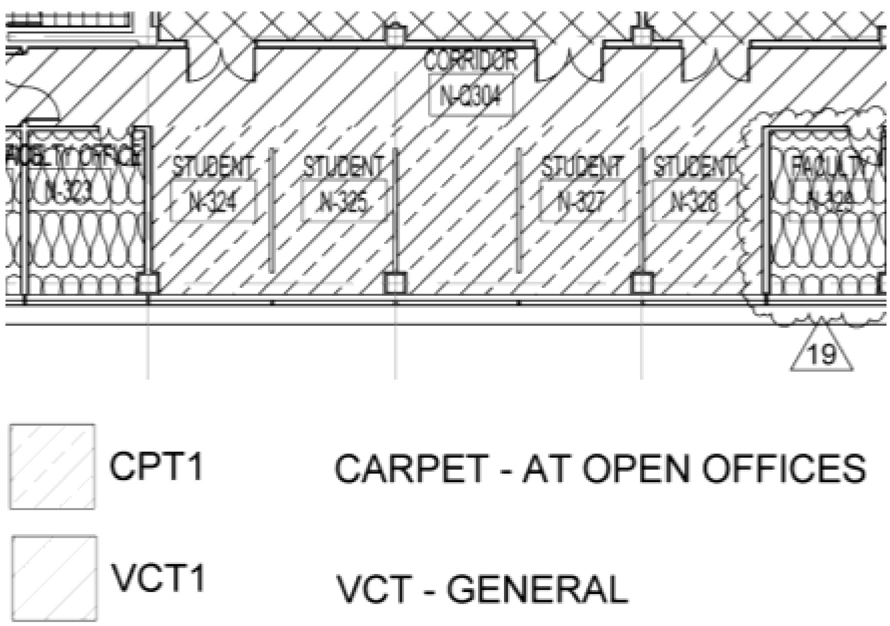

***Figure 28**:* Corridor/Study Area Finish Floor Plan.

Fixture Cut Sheets

See Appendix pages for the following specific fixture cut sheets:

DC-1	EL-5	NF-1B-d1	NF-5-d1
DC-1A	NF-1	NF-5	NF-10
DC-4-d1			

Existing Conditions Verification

The following section contains an evaluation of the existing lighting design for three spaces: a third floor seminar room, third floor café/lounge area, and the third floor corridor/study area. The spaces were evaluated in AGi32 to determine horizontal and vertical illuminance values.

Seminar Room

Seminar Room		
Surface	Reflectance Value	Transmittance Value
Gypsum Ceiling	0.86	
ACT Ceiling	0.78	
Door Glazing		0.5
Door**	0.5	
Door Trim**	0.5	
Floor**	0.13	
Floor Molding**	0.3	
Shelving**	0.5	
Wall	0.76	
Wall Paneling	0.23	
**Values from AGi32 swatches for similar materials		

***Table 7**:* Surface reflectance/transmittance values

Light Loss Factor[1] Sample Calculations for DC-1A

Luminaire Dirt Depreciation

12 month cleaning interval

W curve for Direct Fixture = .93

Lamp Lumen Depreciation

= (Mean Lumens/Initial Lumens)

= (2690/3200)

= .84

Room Surface Dirt Depreciation

RCR = (5H x (W + L)) / (L x W)

RCR = 5(10) x (18.5 + 42.5)) / (42.5 x 18.5)

RCR = 3.88

Direct Curve = .95

Ballast Factor

Advance Transformer Ballast = .98

Total Light Loss Factor

= (LDD x LLD x RSDD x BF)

= (0.93 x 0.84 x 0.95 x 0.98)

= 0.73

[1] IESNA Chapter 9

Light Loss Factors - Seminar Rom					
Fixture Type	LDD	LLD	RSDD	BF	Total LLF
DC-1A	0.93	0.84	0.95	0.98	0.73
DC-4d1	0.93	0.84	0.95	1.00	0.74
NF-1Bd1	0.93	0.94	0.95	1.00	0.83
*LDD calculated from new IESNA guidelines for Clean Environment based on 12 month cleaning interval.					

***Table 8**:* Light Loss Factors

AGi32

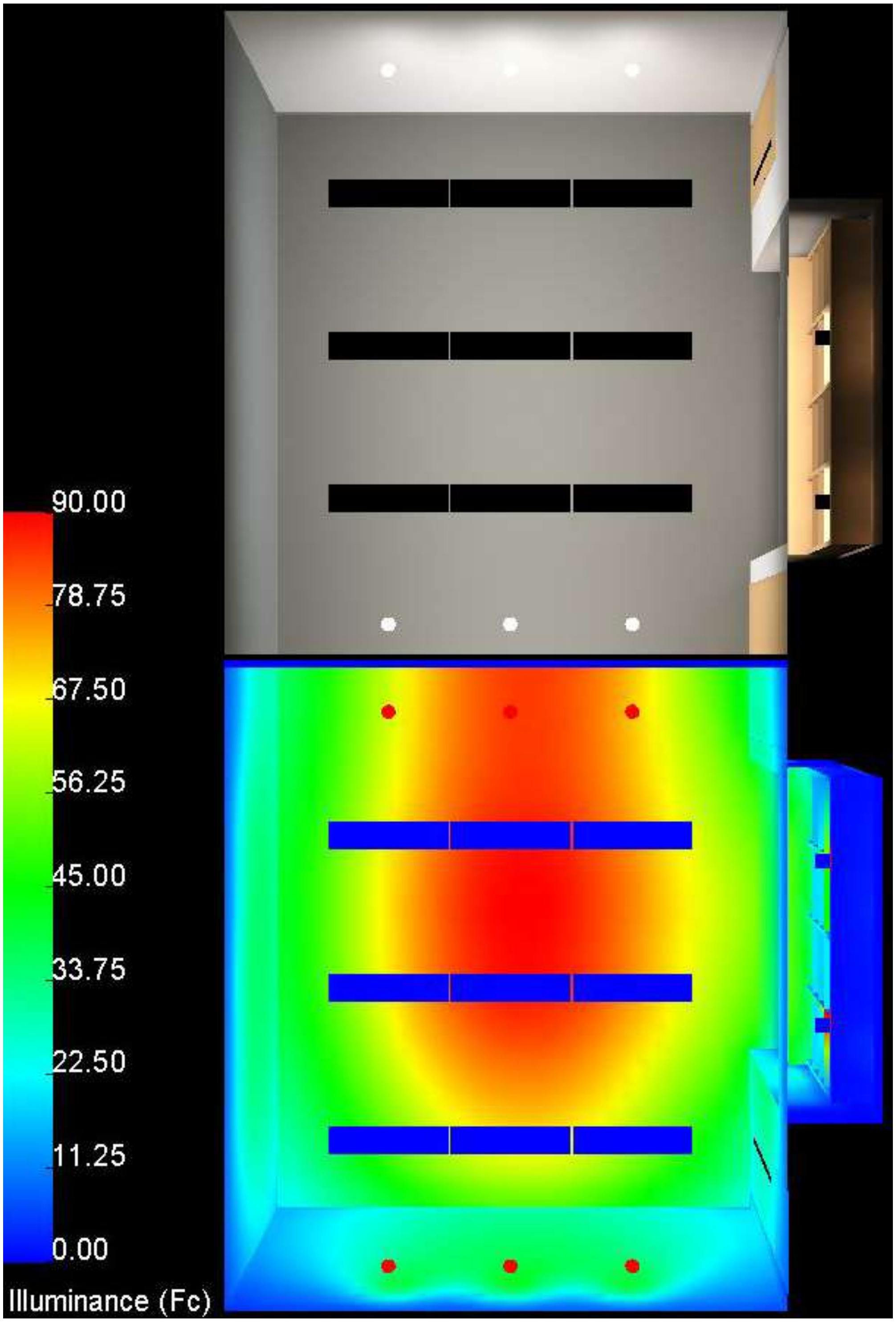

***Figure 29**:* AGi32 Plan Renderings.

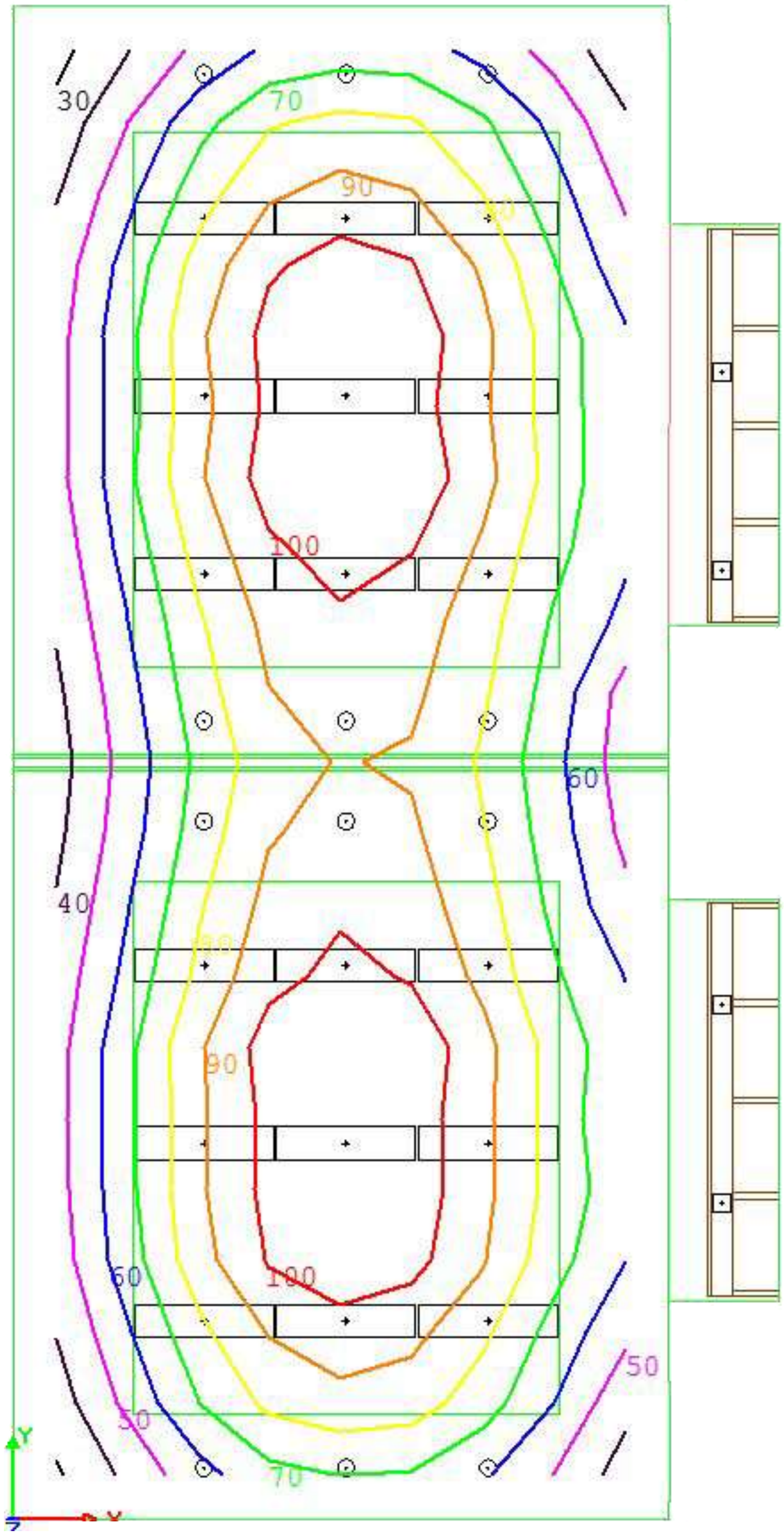

***Figure 30**:* AGi32 Illuminance Contour Lines.

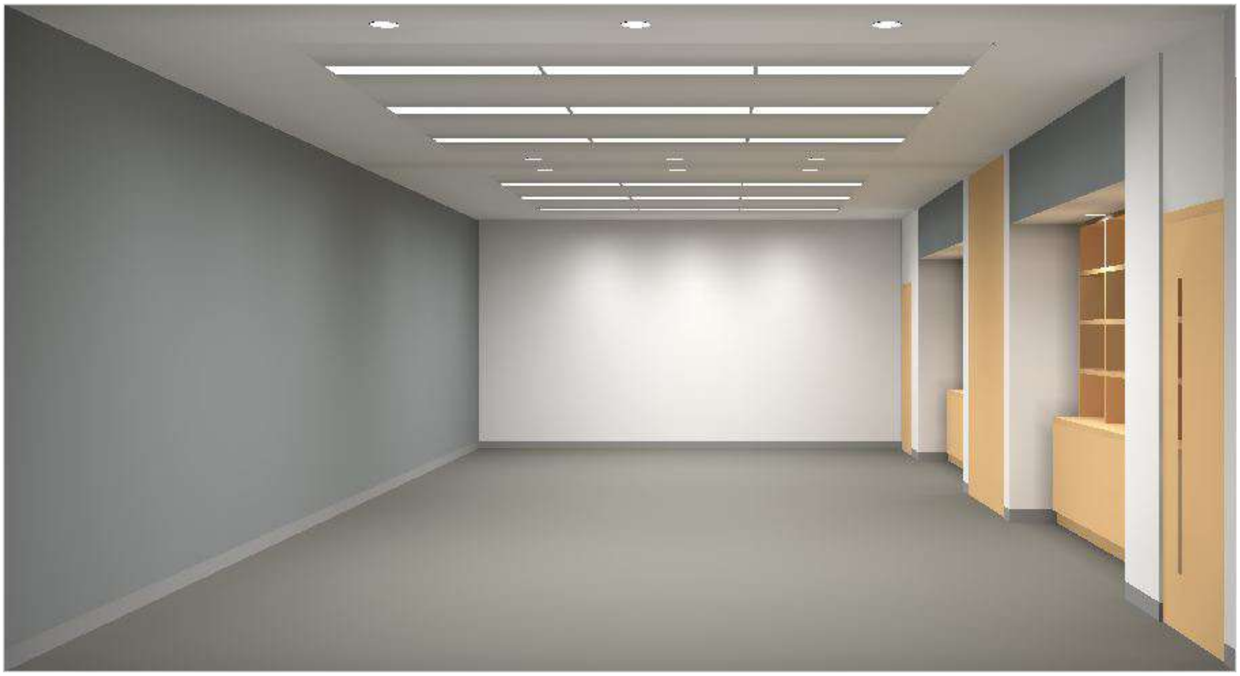

***Figure 31**: AGi32 Perspective Rendering.*

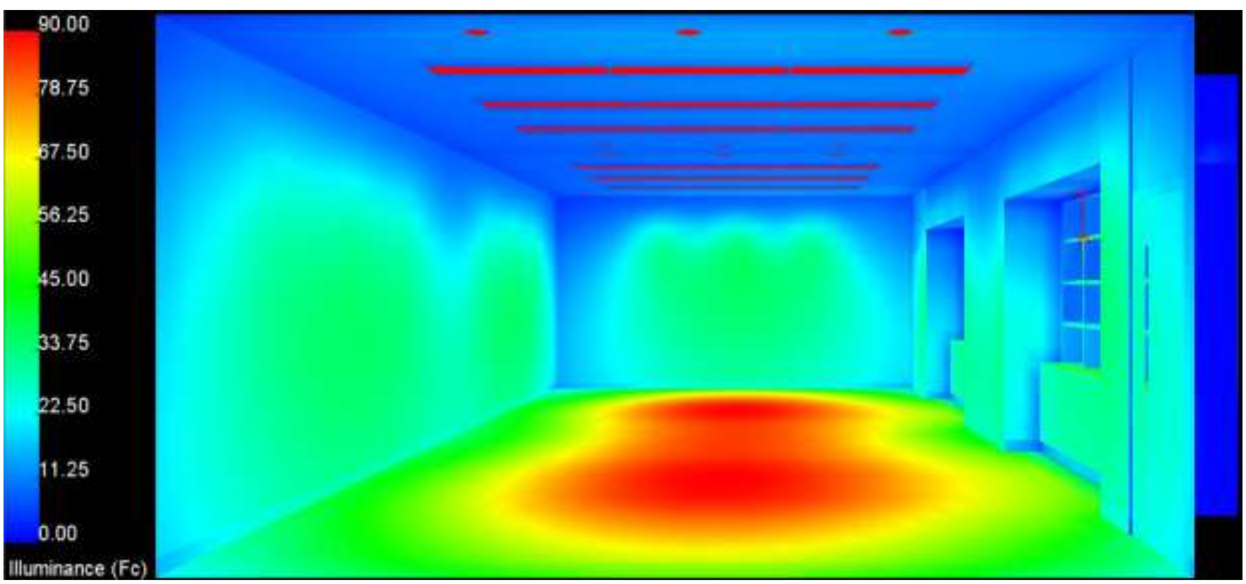

***Figure 32**: AGi32 Perspective Pseudo Rendering.*

Seminar Room - Work Plane Horiz. Illuminance			
Max Illuminance	111fc	Minimum Illuminance	26.8fc
Max/Min	4.14	Avg./Min	2.76

Table 9: Horizontal Illuminance

Seminar Room -4' Vertical Illuminance			
Max Illuminance	38.2fc	Minimum Illuminance	11.4fc
Max/Min	3.35	Avg./Min	2.29

Table 10: Vertical Illuminance

Seminar Room		
	Design Criteria	Actual Values
Meeting Tasks		
	30fc Horizontal	74fc
	5fc Vertical	26.16fc
Video Conferencing		
	50fc Horizontal	74fc
	30fc Vertical	26.16fc

Table 11: IESNA Value Comparisons

Lighting Power Density

Seminar Room - LPD				
Fixture Type	Number of Fixtures	Watts/Fixture	Watts	
DC-1A	4	36	144	
DC-4d1*	12	37.5	450	
NF-1Bd1	18	67	1206	
*2 fixtures per ballast			1800	= Total Watts
		Total Area =	837	
			2.15	= Watts/ft^2

Table 12: LPD Calculations

Lighting Power Density		
Space	ASHRAE 90.1 Allowable	Actual
Seminar Room		
Conference Room	1.3W/ft^2	2.15W/ft^2

Table 13: ASHRAE 90.1 LPD Comparisons

Critique

The lighting design for the seminar room in Millennium Science Complex although aesthetically pleasing exceeds most IESNA criteria. The horizontal illuminance levels in the space are more than double the required levels at maximum output. The vertical illuminance levels are well above meeting task requirements, but much closer to those required for video conferencing. The lighting design also fails to meet maximum lighting power density requirements of ASHRAE 90.1, the allowable W/ft^2 is 1.3 and the actual is 2.15W/ft^2.

The lighting design does meet considerations for a multiuse space. The open space has a uniform illuminance level, although too high. The all-direct system may create issues regarding glare with VDT. The location of the luminaires works well aesthetically, along with providing light to the proper areas of the room for the room's range of tasks. The lighting levels can be reduced by dimming the linear fluorescent fixtures in the center of each seminar room which helps provide a flexible lighting design that can adapt to different tasks.

Café/Common Area

Common Area		
Surface	Reflectance Value	Transmittance Value
Gypsum Ceiling	0.86	
ACT Ceiling	0.78	
Cooler**	0.1	
Door Glazing		0.5
Door **	0.5	
Door Trim**	0.5	
Exterior Glazing		0.7
Floor	0.5	
Kitchen Floor	0.5	
Mullions	0.55	
Table**	0.5	
Walls	0.76	
**Values from AGi32 swatches for similar materials		

Table 14: Surface reflectance/transmittance Values

Light Loss Factor[1] Sample Calculations for NF-5

Luminaire Dirt Depreciation

12 month cleaning interval

W curve for Direct Fixture = .93

Lamp Lumen Depreciation

= (Mean Lumens/Initial Lumens)

= (2827/3007)

= .94

Room Surface Dirt Depreciation

RCR = (5H x (W + L)) / (L x W)

RCR = 5(11) x (45+ 60)) / (60 x 45)

RCR = 2.14

Direct Curve = .96

Ballast Factor

Advance Transformer Ballast = .88

Total Light Loss Factor

= (LDD x LLD x RSDD x BF)

= (0.93 x 0.94 x 0.96 x 0.88)

= 0.74

[1] IESNA Chapter 9

Light Loss Factors - Common Area					
Fixture Type	LDD	LLD	RSDD	BF	Total LLF
DC-1A	0.93	0.84	0.96	0.98	0.74
NF-5**	0.93	0.94	0.96	0.88	0.74
NF-5d1	0.93	0.94	0.96	1.00	0.84
NF-10**	0.93	0.94	0.96	0.88	0.74
PC-1	0.84	0.94	0.96	0.98	0.74
*LDD calculated from new IESNA guidelines for Clean Environment based on 12 month cleaning interval.					
**Specs call for min ballast factor ≥ .9 for T8 fixtures					

Table 15: Light Loss Factors

AGi32

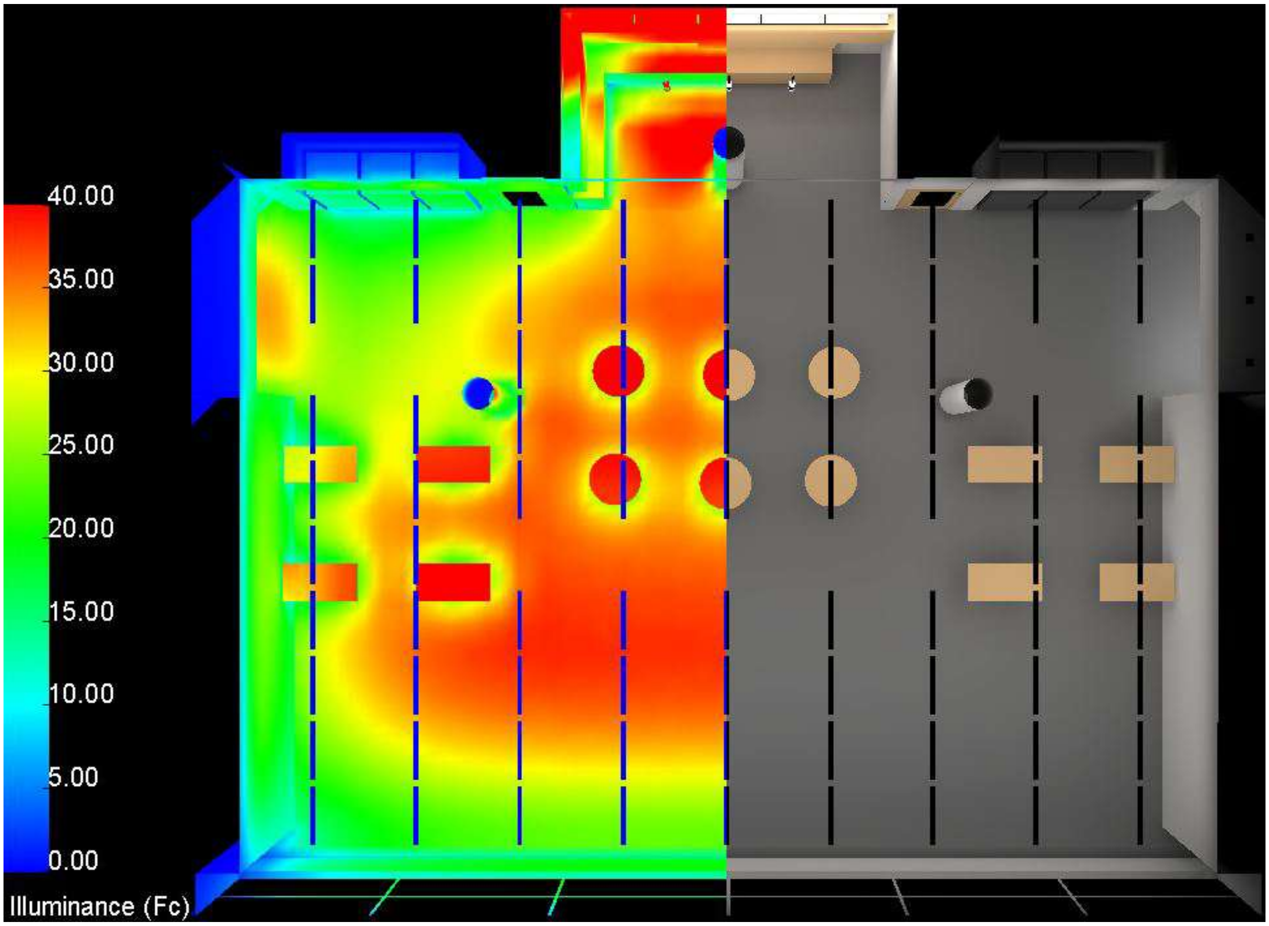

Figure 33: AGi32 Plan Rendering.

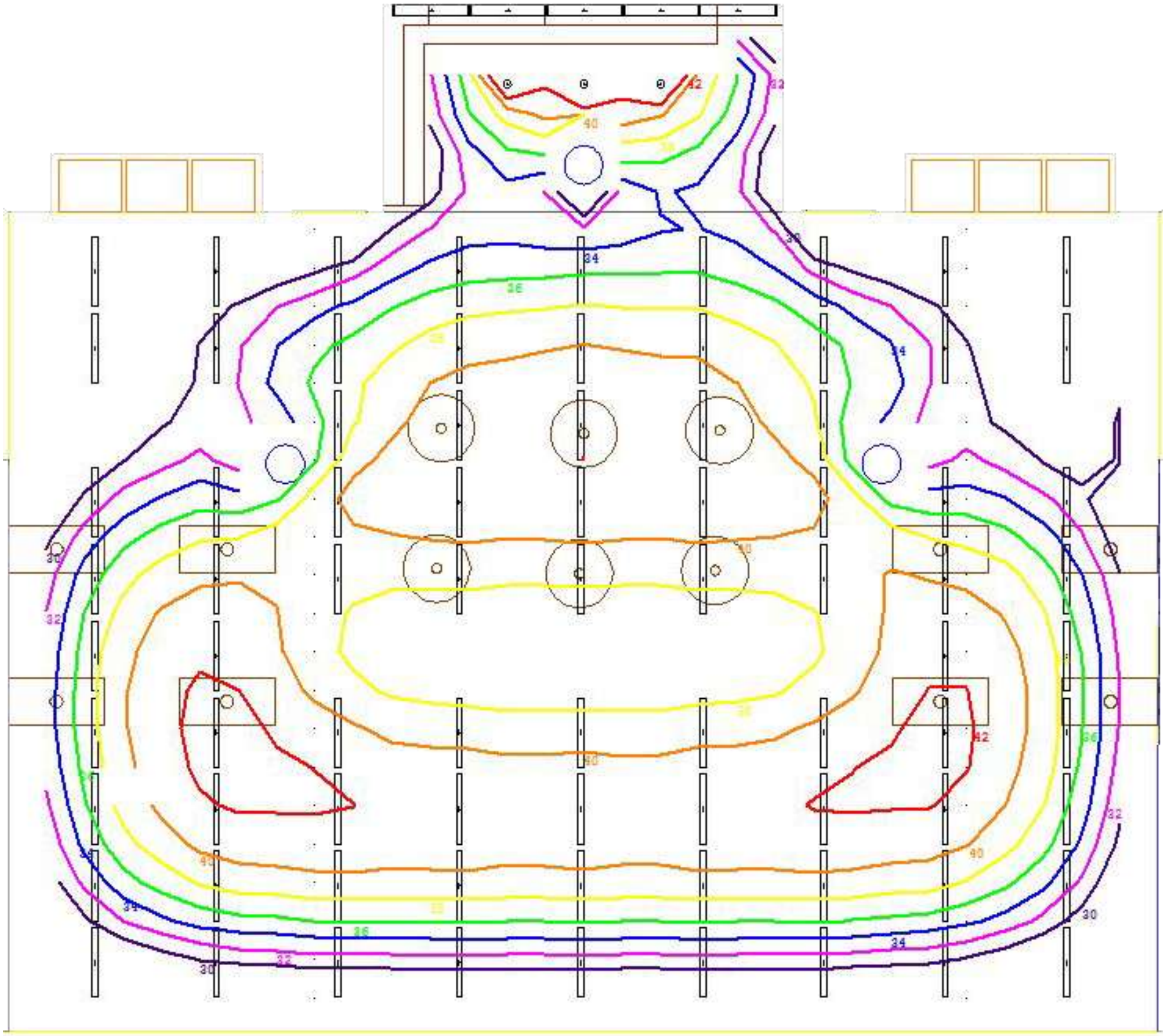

Figure 34: AGi32 Illuminance Contour Lines.

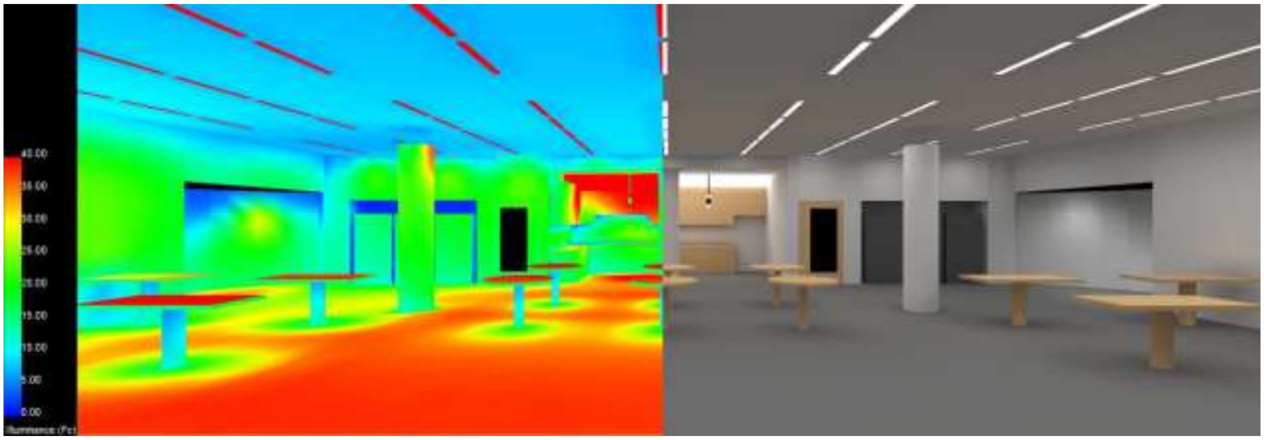

***Figure 35**:* AGi32 Perspective Rendering.

Common Area - Work Plane Horizontal Illuminance			
Max Illuminance	42.6fc	Minimum Illuminance	16.9fc
Max/Min	2.52	Avg./Min	2.08

***Table 16**:* Horizontal Illuminance

Common Area -4' Vertical Illuminance			
Max Illuminance	25fc	Minimum Illuminance	6.3fc
Max/Min	3.97	Avg./Min	2.82

***Table 17**:* Vertical Illuminance

Common Area		
	Design Criteria	Actual Values
Food Courts		
	30fc Horizontal	35fc
	3fc Vertical	17.75fc
Dinning		
	10fc Horizontal	35fc
	3 fc Vertical	17.75
Food Displays		
	50fc Horizontal	35fc

***Table 18**:* IESNA Value Comparisons

Lighting Power Density

Common Area - LPD			
Fixture Type	Number of Fixtures	Watts/Fixture	Total Watts
NF-5	33	59	1947
NF-5d1	48	67	3216
NF-10	5	59	295
PC-1	3	36	108

5566 = Total Watts

Total Area = 3021

1.84 = Watts/ft^2

***Table 19**:* LPD Calculations

Lighting Power Density		
Space	ASHRAE 90.1 Allowable	Actual
Café/Commons		
Dining Area	1.3W/ft^2	1.84W/ft^2
Food Preparation	1.3W/ft^2	

***Table 20**:* ASHRAE 90.1 LPD Comparisons

Critique

The lighting design for the café/common area is once again aesthetically pleasing. The space once again exceeds most IESNA criteria. The horizontal illuminance levels are slightly higher than the recommended values. The vertical illuminance levels are high, and then there is not enough light for the food displays. The lighting design fails to meet maximum lighting power density requirements of ASHRAE 90.1 – the allowable W/ft^2 is 1.3 and the actual is 1.84W/ft^2.

The space utilizes linear strips of light and provides a good uniformity throughout the space. The direct component may create glare issues not only with personal computers, but also with video walls located within the space. The café/common area also utilizes natural light. This is achieved through motorized shades and dimmable fixtures. The use of natural light helps to enhance the occupant's perception of the space.

Corridor/Study Area

Corridor/Study Area		
Surface	Reflectance Value	Transmittance Value
ACT Ceiling	0.76	
Carpet	0.13	
Cubicles**	0.22	
Door**	0.5	
Exterior Glazing		0.7
VCT Floor**	0.88	
Walls	0.76	
**Values from AGi32 swatches for similar materials		

***Table 21**: Surface Reflectance Values*

Light Loss Factors - Corridor/Study Area					
Fixture Type	LDD	LLD	RSDD	BF	Total LLF
NF-1	0.93	0.94	0.95	0.88	0.73
NF-1Bd1	0.93	0.94	0.95	1.00	0.83
*LDD calculated from new IESNA guidelines for Clean Environment based on 12 month cleaning interval					

***Table 22**: Light Loss Factors*

Light Loss Factor[1] Sample Calculations for NF-1

Luminaire Dirt Depreciation
- *12 month cleaning interval*
- *W curve for Direct Fixture = .93*

Lamp Lumen Depreciation
- *= (Mean Lumens/Initial Lumens)*
- *= (2827/3007)*
- *= .94*

Room Surface Dirt Depreciation
- *RCR = (5H x (W + L)) / (L x W)*
- *RCR = 5(11) x (20+ 54)) / (54 x 20)*
- *RCR = 3.8*
- *Direct Curve = .95*

Ballast Factor
- *Advance Transformer Ballast = .88*

Total Light Loss Factor
- *= (LDD x LLD x RSDD x BF)*
- *= (0.93 x 0.94 x 0.95 x 0.88)*
- *= 0.73*

[1] IESNA Chapter 9

AGi32

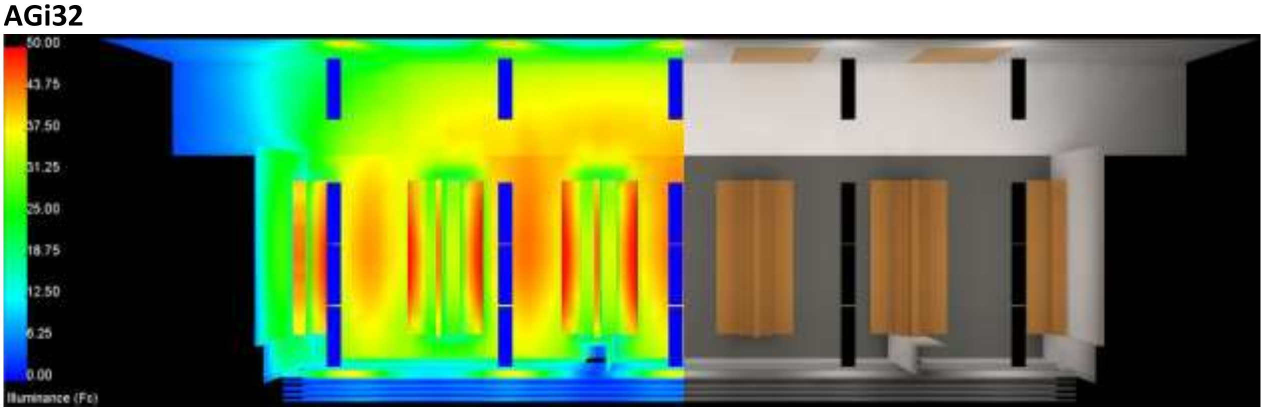

***Figure 36**: AGi32 Plan Rendering.*

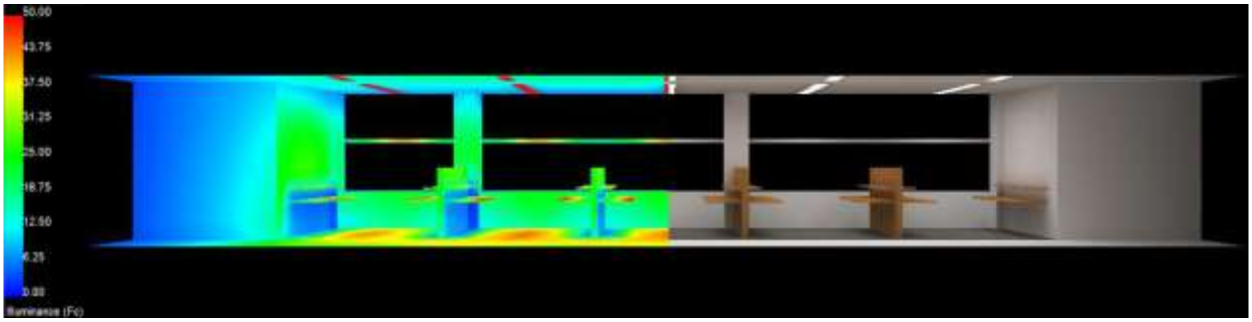

***Figure 37**:* AGi32 Perspective Rendering.

Student Study Area - Work Plane Horizontal Illuminance			
Max Illuminance	63.9fc	Minimum Illuminance	1.9fc
Max/Min	33.63	Avg./Min	2.93

***Table 23**:* Horizontal Illuminance

Common Area -4' Vertical Illuminance			
Max Illuminance	25fc	Minimum Illuminance	6.3fc
Max/Min	3.97	Avg./Min	2.82

***Table 24**:* Vertical Illuminance

Student Area Corridor - Work Plane Horizontal Illuminance			
Max Illuminance	40.7fc	Minimum Illuminance	22.7fc
Max/Min	1.79	Avg./Min	1.54

***Table 25**:* Horizontal Illuminance

Student Area Corridor -4' Vertical Illuminance			
Max Illuminance	29.2fc	Minimum Illuminance	7.6fc
Max/Min	3.84	Avg./Min	1.54

***Table 26**:* Vertical Illuminance

Student Area		
	Design Criteria	Actual Values
Study Areas		
	30-50fc Horizontal	42.93fc
	3fc Vertical	18.64fc
Corridors		
	5fc Horizontal	35fc

***Table 27**:* IESNA Value Comparisons

Lighting Power Density

Student Area - Corridor			
Fixture Type	Number of Fixtures	Watts/Fixture	Total Watts
NF-1B	5	59	295

***Table 28**:* LPD

295 = Total Watts
Total Area = 380
0.78 = Watts/ft^2

Student Area - Study Area			
Fixture Type	Number of Fixtures	Watts/Fixture	Total Watts
NF-1Bd1	15	67	1005

***Table 29**:* LPD

1005 = Total Watts
Total Area = 813
1.24 = Watts/ft^2

Lighting Power Density		
Space	ASHRAE 90.1 Allowable	Actual
Student Area		
Corridor	0.5W/ft^2	0.78W/ft^2
Study Area	1.2W/ft^3	1.24W/ft^3

***Table 30**:* ASHRAE 90.1 LPD Comparisons

Critique

The lighting design for the corridor/study areas utilizes rows linear fluorescent fixtures over study areas. The space exceeds most IESNA criteria. The study area is well designed where the horizontal illuminance falls within the recommended range. The vertical illuminance levels are higher than the recommended values. The lighting design fails to meet maximum lighting power density requirements of ASHRAE 90.1, the allowable W/ft^2 is 0.5 and the actual is 0.78W/ft^2 for the corridor, and the allowable W/ft^2 is 1.2 and the actual is 1.24W/ft^2 for the study area.

The space utilizes linear fixtures and provides a good uniformity throughout the study space. The direct component may create glare issues with personal computers. The spill light from the study area into the corridor breaks up the uniformity of the corridor. This study area utilizes natural light by using shades and dimmable fixtures.

Daylight Study

Daylighting was considered in the architectural and electrical design of the Millennium Science Complex. The architectural daylighting features of the building are large over hangs on at each end of both wings (Figure 38), and a continuous louvered overhang around entire perimeter of the building (Figure 39). The architect also chose to use both manual and motorized shades on the exterior glazing. The common spaces make use of motorized shades, where the private offices utilize manual shades. In the Material Science wing, the private offices have upper glazing on the wall in an attempt to provide natural light into the corridors.

Electrically, common spaces use luminaires with dimming ballasts. These luminaires are tied into daylight sensors which will decrease electric light output in the spaces accordingly. Private offices utilize daylighting based on occupant preferences; the occupant chooses when the shades are used, and also when lights should be utilized.

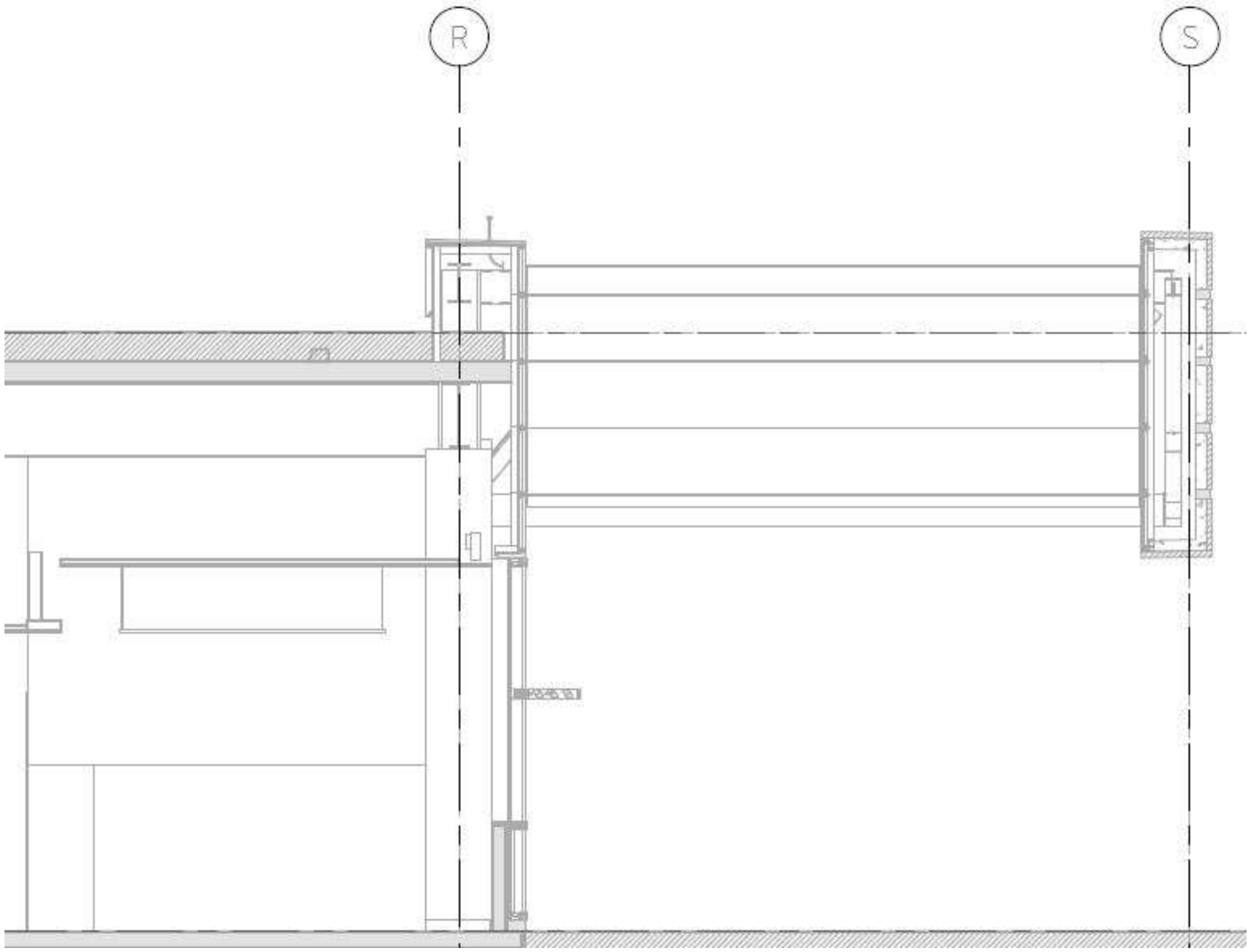

***Figure 38**:* Section of Large Overhangs

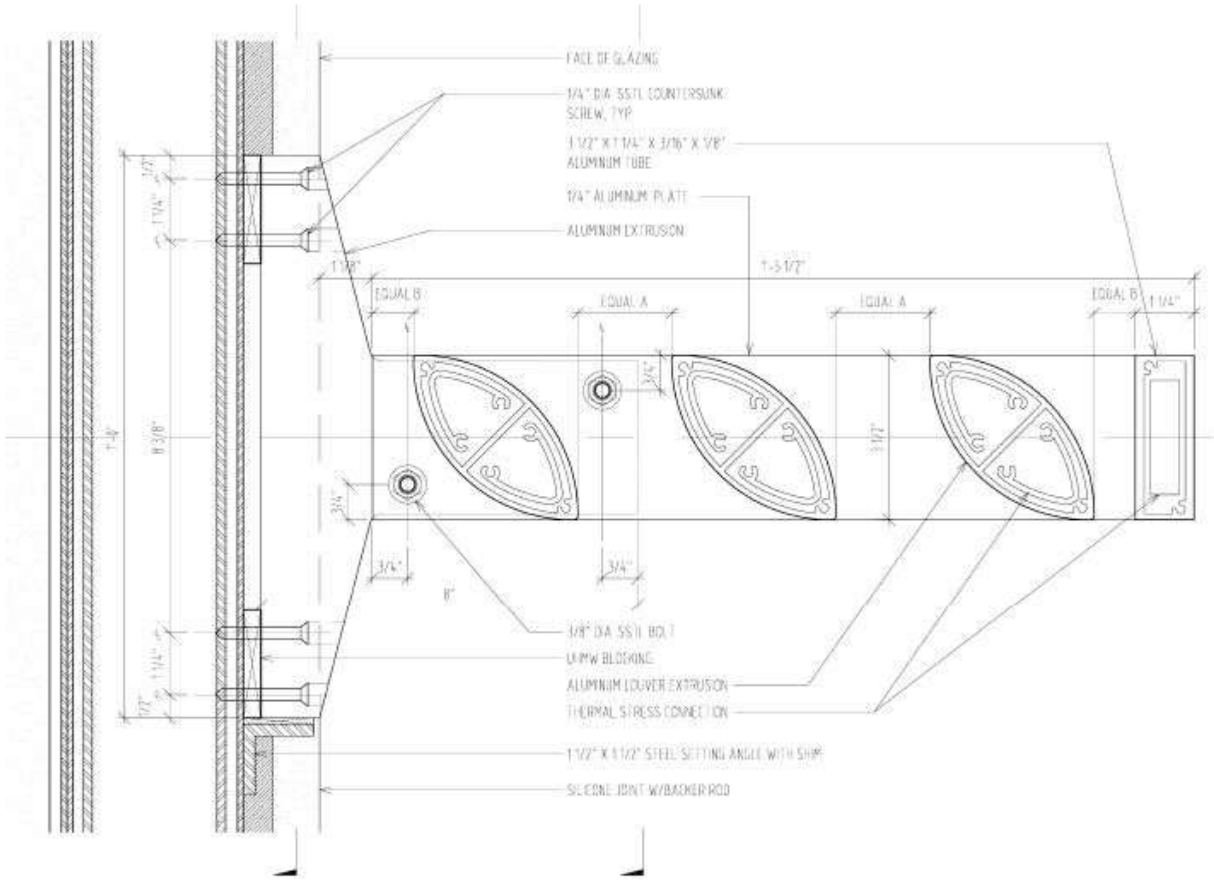

Figure 39*:* Section of Continuous Louvered Overhang.

Office Daylighting Analysis

This section includes a Daysim analysis of a typical private office containing only the continuous louvered overhang. The analysis includes Daylight Autonomy and Continuous Daylight Autonomy for each the North, South, East, and West facing façade at 30fc and above.

Office		
Surface	Reflectance Value	Transmittance Value
Gypsum Ceiling	0.86	
ACT Ceiling	0.76	
Door	0.5	
Door Trim	0.5	
Exterior Glazing		0.7
Floor	0.13	
Mullions	0.55	
Interior Glazing		0.5
Shade		0.1
Walls	0.76	
**Values from AGi32 swatches for similar materials		

***Table 31**:* Surface reflectance/transmittance values.

Daysim Results
The following are sample results from Daysim for the North Façade (other facades can be found in the appendix).

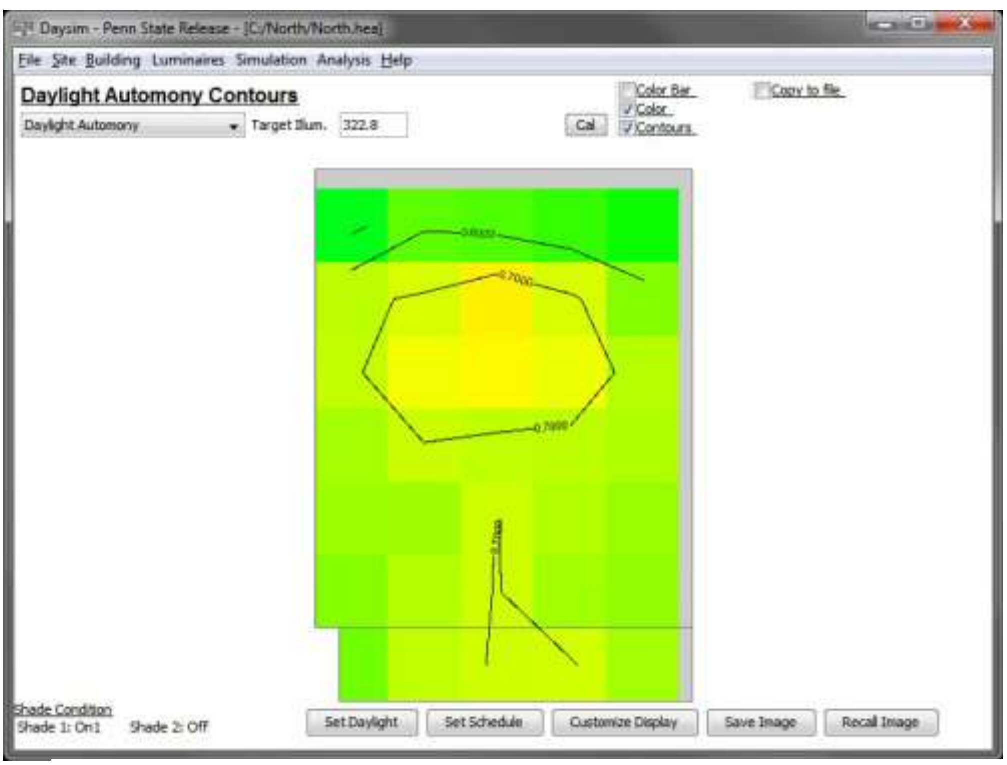

***Figure 40**:* 30fc Daylight Autonomy – North Facade

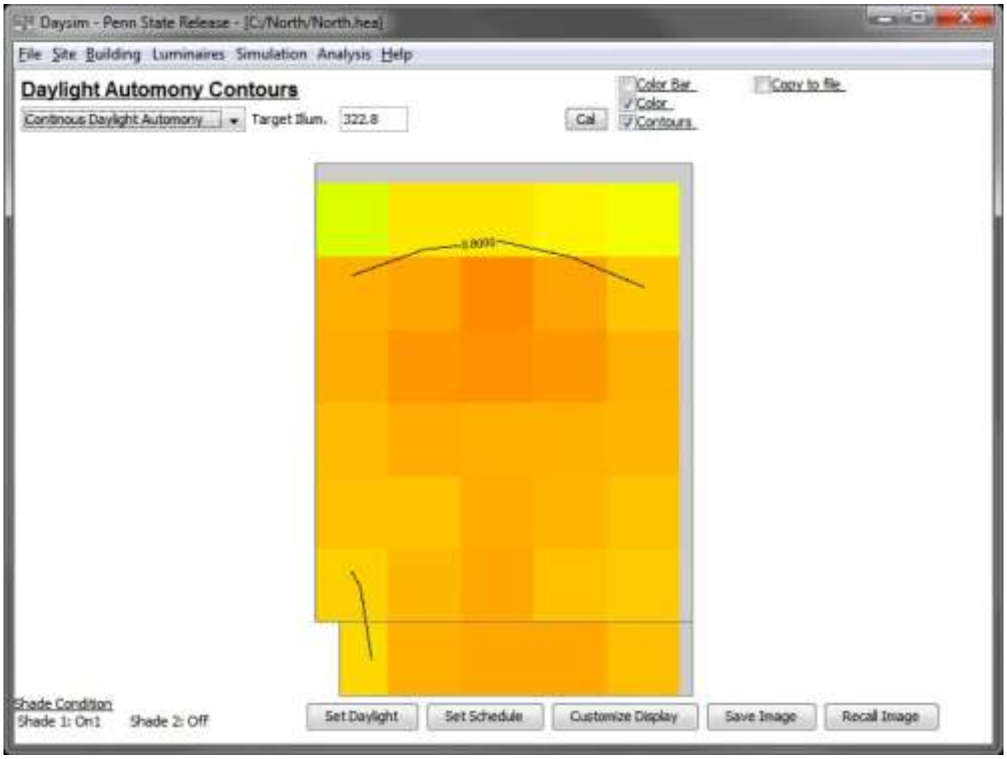

***Figure 41**:* 30fc Continuous Daylight Autonomy – North Facade

Daylight Analysis

The daylighting system is effective in private offices; the space receives 30fc of daylighting approximately 70 percent of the time. The system in the office is fully dependent on occupant preference; therefore it's difficult to determine if the system would be operated optimally to maximize energy savings. The integration of automatic shades along with dimming in the private offices would increase energy savings, but they payback period may be too large.

Although from the Daysim models the system appears to work very well for the private offices there are several areas that could be approved. By implementing façade specific overhangs and light shelves energy savings could be greatly improved. Also in order to prevent glare issues involved with excessive direct sunlight vertical shading could be utilized on the east and west facing facades. The overall daylighting system for the Millennium Science Complex appears to be based more on aesthetics of the façade than true performance of the system.

Assigning Design Criteria in RevitMEP

Now that design criteria has been examined in previous sections, this section of Technical Assignment I examines how lighting design criteria can be entered into BIM software, such as Revit MEP. Platforms under examination are AutoDesk Revit MEP 2011 and Autodesk Revit Architecture 2011. Several topics will be examined including the following:

Entering Material Properties
Setting Design Criteria
Calculation Process in Revit MEP

Entering Material Properties

Professionals who have used platforms of AutoDesk Revit are usually familiar with the materials editing process, but not to the level of detail that can be fully achieved with the programs. With respect to lighting design, the generic material types in Revit MEP simply are not enough to provide detailed renderings of spaces, which keep lighting design out of BIM. Embedded within the material properties of Revit Architecture are custom materials. In order to appropriately model surfaces such as "painted gypsum wall board with [manufacturer] cool gray paint," the designer should use a custom wall.

When going deeper into the wall construction and materials, the user will notice that there is not much room for customization in the generic Revit material types. For example, the standard gypsum wall board acts like a painted surface (Figure 42). There are pre-loaded properties of finishes in the following combinations of color, finish, and application:

Color	Finish	Application
Customizable	Flat/Matte	Brush
	Eggshell	Roller
	Platinum	Spray
	Pearl	
	Semi-gloss	
	Gloss	

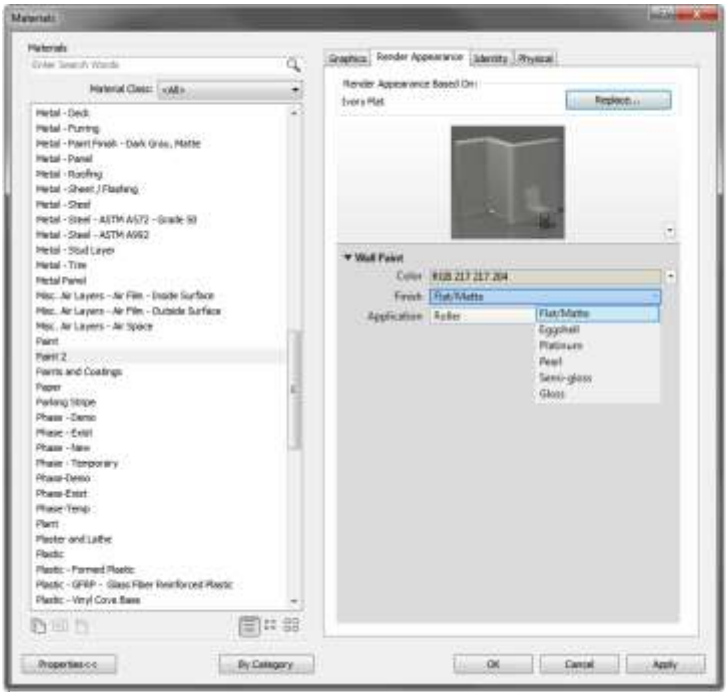

***Figure 42**:* Material Properties - Finishes

Each of these finishes and applications has properties of reflectance, specularity, roughness, etc. that cannot be accessed by the designer. A good way to make the surface somewhat custom to the design is to begin with a "Generic" material and adjust colors and reflectivity (Figure 43).

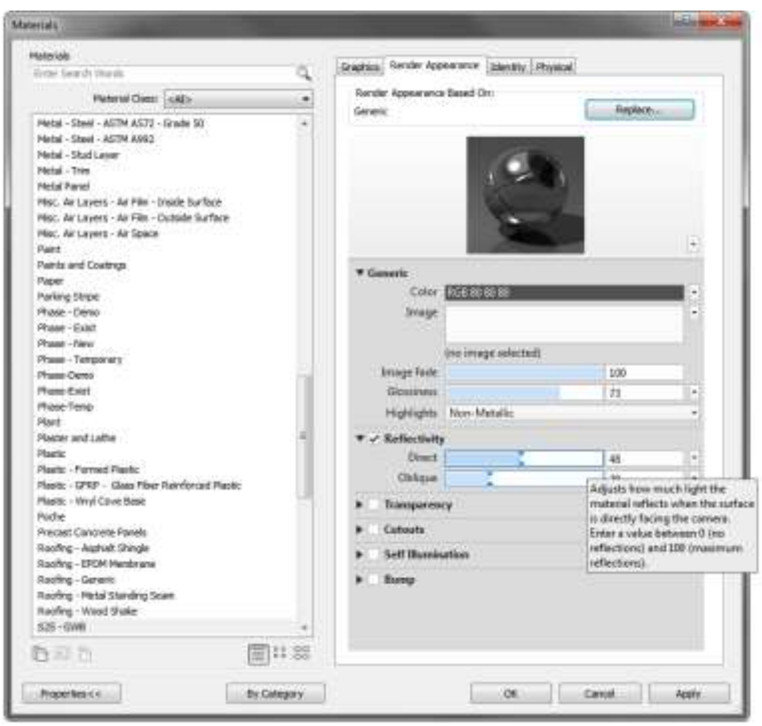

***Figure 43**:* Material Properties – Custom Finishes

These properties, however, are not exactly the inputs lighting designers wish to be able to control. The direct reflectivity and oblique reflectivity are defined by Revit Architecture as follows:

> Direct Reflectivity: Measurement of how much light the material reflects when the surface is directly facing the camera. Enter a value between 0 (no reflections) and 1 (maximum reflections).

> Oblique Reflectivity: Measurement of how much light the material reflects when the surface is at an angle to the camera. Enter a value between 0 (no reflections) and 1 (maximum reflections).

This means that designers must perform a calculation to find the relative reflectivity of their surfaces, or guess and hope that their inputs are somewhat accurate. On the positive end, there are materials that do have relative inputs. Glass types allow the designer to input reflectance and number of sheets in the panel. Glass types do not, however, allow for specification of transmittance. Without usable inputs such as reflectance, instead of reflectivity, and transmittance, instead of transparency, lighting design in platforms of Revit is simply too time consuming and not worth the input relative to programs such as AGI32.

Setting Design Criteria

One of the largest challenges of lighting designers is establishing appropriate design criteria for spaces. The discussion up to this section has been design criteria for three spaces in the Millennium Science Complex. With the advent of Building Information Modeling, lighting design has an opportunity to merge into a larger world than lighting software. In its current state, building information modeling lacks in ultimate usefulness of design criteria such as design illuminance and other measurable quantities such as uniformity gradient, coefficient of variance, and luminance ratios. However, this observation is only applicable to Revit MEP 2011 as it is the primary software for IPD/BIM Thesis 2010-2011.

Revit MEP allows for specialized space criteria once a schedule is created. It is possible to add custom parameters, but it is not possible to edit pre-loaded templates (Figure 44). Other information, such as power densities (similar to ASHRAE 90.1) is already embedded into space types. It is possible to add custom parameters through schedules (Figure 45).

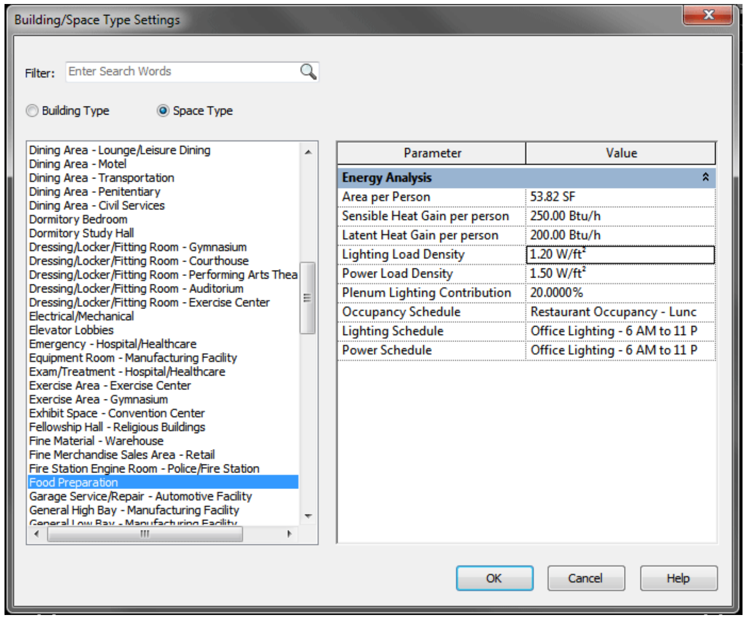

***Figure 44**:* Space Type

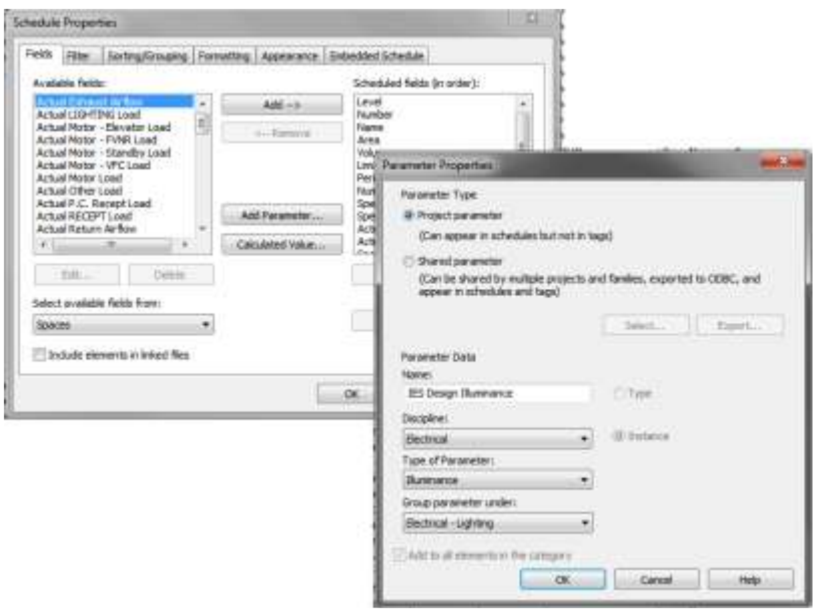

***Figure 45**:* Parameter Properties

For the inputs above, the parameter "IES Design Illuminance" will appear under the "Electrical – Lighting" properties of the space and be in "Illuminance" parameters (i.e. footcandles). Now that this parameter has been created, each space can be edited to have its IES recommended illumination value within its properties. These new parameters can be drawn out of the BIM model in a schedule, but are arbitrary to space type. Not being associated with a pre-specified space type creates a labor-intensive chore to assign design criteria to spaces.

If IES values and parameters can be associated in the base space types, then it will be possible to have a visual check on initial space design compliance. Discussed in the next section will be how Revit calculates average illuminance values and their comparison to actual hand calculations.

Calculation Process Revit MEP

Embedded in space types as discussed in “Setting Design Criteria” of this document are calculated statistics applicable to lighting design. Parameters for these calculations include:

Variable Inputs	Outputs
Lighting Calculation Work Plane	Average Estimated Illumination (AEI)
Ceiling Reflectance	Room Cavity Ratio (RCR)
Wall Reflectance	
Floor Reflectance	

These inputs are separate from the “reflectivity” parameters discussed in the previous topic. The reflectances in this topic are applied to the space. The space is essentially an imaginary box that fills a room to its extents. The reflectance values apply to the ceiling, walls, and floor of the space box and are not associated with the materials in the room whatsoever. Each reflectance can be thought of as an area average for the entire area it is analogous to in the space.

The room cavity ratio is automatically calculated from the “lighting calculation work plane” and the mounting height of the luminaire. All calculations are used in a basic Lumen Method for the space. This inherently cannot take criteria such as vertical illuminance, actual uniformity, or luminance ratios as discussed in the last topic. Other inputs are available that affect the calculation such as customizable light loss factors and initial intensity (by efficacy, flux, luminous intensity, or illuminance at a distance). The image from Revit MEP’s help site below shows these inputs (Figures 46 and 47). These all are combined into a total light loss factor for the calculation.

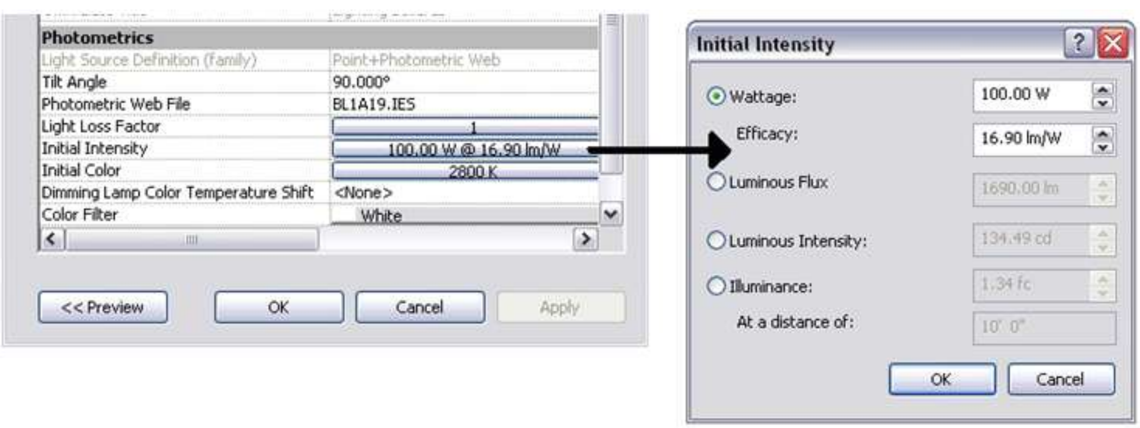

***Figure 46**:* Initial Intensity

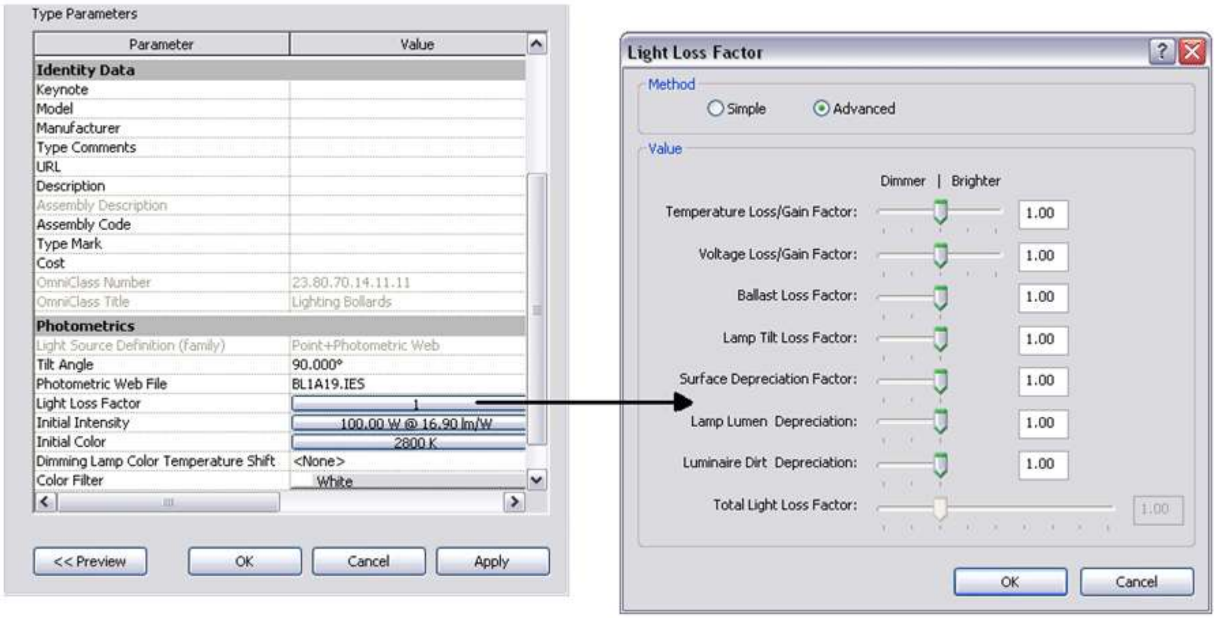

***Figure 47**:* Light Loss Factors

Revit's calculation process incorporates all of the input factors from each luminaire and adds them individually. Regardless of luminaire position, orientation, and distribution, a simple addition of flux is the only equation used to calculate total illuminance:

$$AEI = \sum_{i=1}^{n} \frac{Lumens\ at\ Workplane_i}{Area}$$

The quantity of lumens at the work plane is a peculiar calculation also. It is a product of the "initial intensity" from the properties seen in the image above, total light loss factors, and the coefficient of utilization of the luminaire. It is unclear in the Revit MEP help page how the coefficient of utilization is actually calculated and used and CU does not appear in an output in the properties box of a space. What the total calculation boils down to is the following:

$$AEI = \sum_{i=1}^{n} \frac{(II * LLF * CU)_i}{Space\ Area}$$

Where: $II = Initial\ Intensity\ in\ lumens$
$LLF = total\ light\ loss\ factors$
$CU = Coefficient\ of\ Utilization$

As the equation turns out, room reflectance values should have direct bearing on the average estimated illumination of the space, as should the task plane height. In reality, the user cannot determine how CU and RCR are used in these calculations. In normal lighting calculations, a room cavity ratio, wall reflectance, and ceiling cavity reflectance are used to interpolate on a chart for the luminaire. In the example below (Figure 48), reflectance values are changed from ceiling/wall/floor of 0.8/0.6/0.2 (standard) to other values.

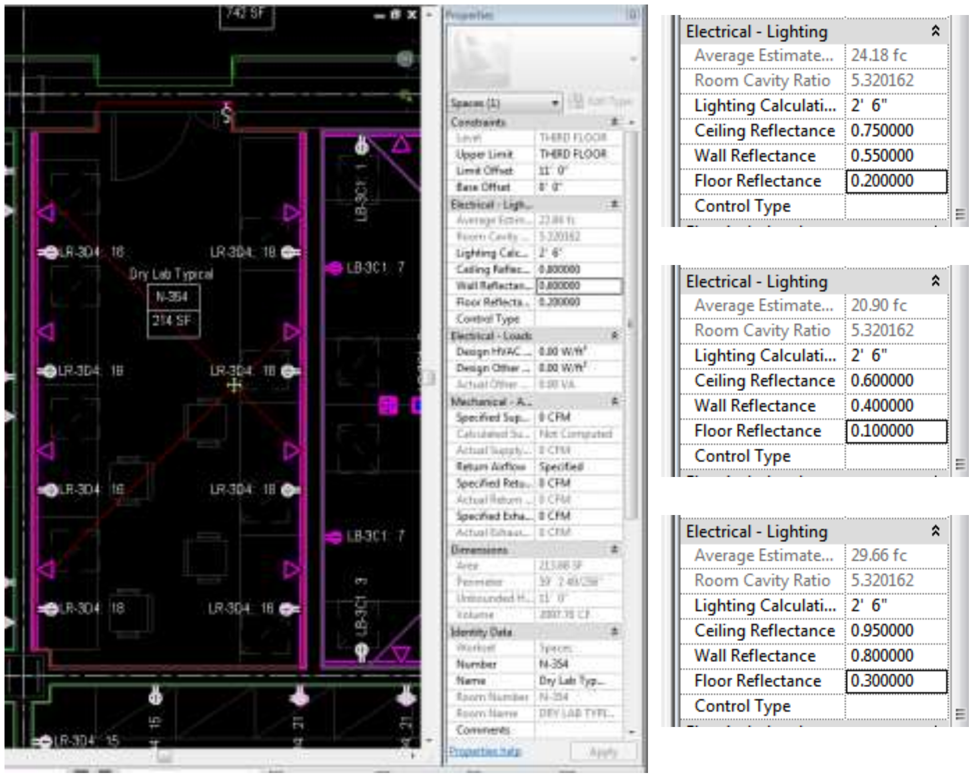

Figure 48: Changing Reflectance Values

Notice the inconsistent change in the calculated illuminance and RCR relative to the given equation. If this calculation were a true Lumen Method, the equations would depend on CU as in the IESNA Handbook shown here:

$$Illuminance = \frac{(\#\ of\ Luminaires)(\varphi\ per\ Luminaire)(CU)(LLF)}{Workplane\ Area}$$

$$Where: \quad CU \propto \quad F(\rho_{CC}, \rho_W, RCR)$$

Upon examining luminaires and spaces, it is possible that the "Room Cavity Ratio" report in the properties dialog is actually a product of RCR and CU. Upon further investigation, this is not true. If reflectances are changed in a space, the coefficient of utilization is automatically changed per luminaire, provided that the "Calculate Coefficient of Utilization" box is checked in the luminaire properties. Using flux transfer, a coefficient of utilization can be obtained that is similar to the value calculated in Revit MEP:

$$\begin{bmatrix} -1 & \rho_1 F_{1-2} & \rho_1 F_{1-3} \\ \rho_2 F_{2-1} & -1 & \rho_2 F_{2-3} \\ \rho_3 F_{3-1} & \rho_3 F_{3-2} & (\rho_3 F_{3-3}) - 1 \end{bmatrix} \begin{bmatrix} M_1 \\ M_2 \\ M_3 \end{bmatrix} = \begin{bmatrix} -M_{01} \\ -M_{02} \\ -M_{03} \end{bmatrix} \qquad CU = \frac{M_{FC} * A_{FC}}{\varphi_{LAMP} * \rho_{FC}}$$

Using the flux balance method, this room has a coefficient of utilization of 0.507 as opposed to a Revit MEP calculated value of 0.518. "Room Cavity Ratio" in Revit MEP is still unclear as to how to achieve this value. For the same room, Revit MEP's output RCR has a value of 5.320. The actual RCR as calculated by the IESNA Handbook has a value of 5.698. When hand-calculated RCR and CU are combined in the Lumen Method equation discussed previously, this room should be calculated to be between 24.80 fc and 30.03 fc depending upon efficiency of the light fixture. Revit MEP calculates the average estimated illumination for this space to be 24.95 fc, which is analogous to an efficiency of 72.7% in the Lumen Method calculation.

In conclusion, Revit MEP's calculation of "average estimated illuminance" can be a good starting point for lighting design, but is not clear enough communicating how these values are calculated. If a more extensive demonstration of how Revit MEP calculates average estimated illuminance can be written into the program, there could be more use for lighting design estimation in Revit.

Appendix – Reference Materials
Typical Types

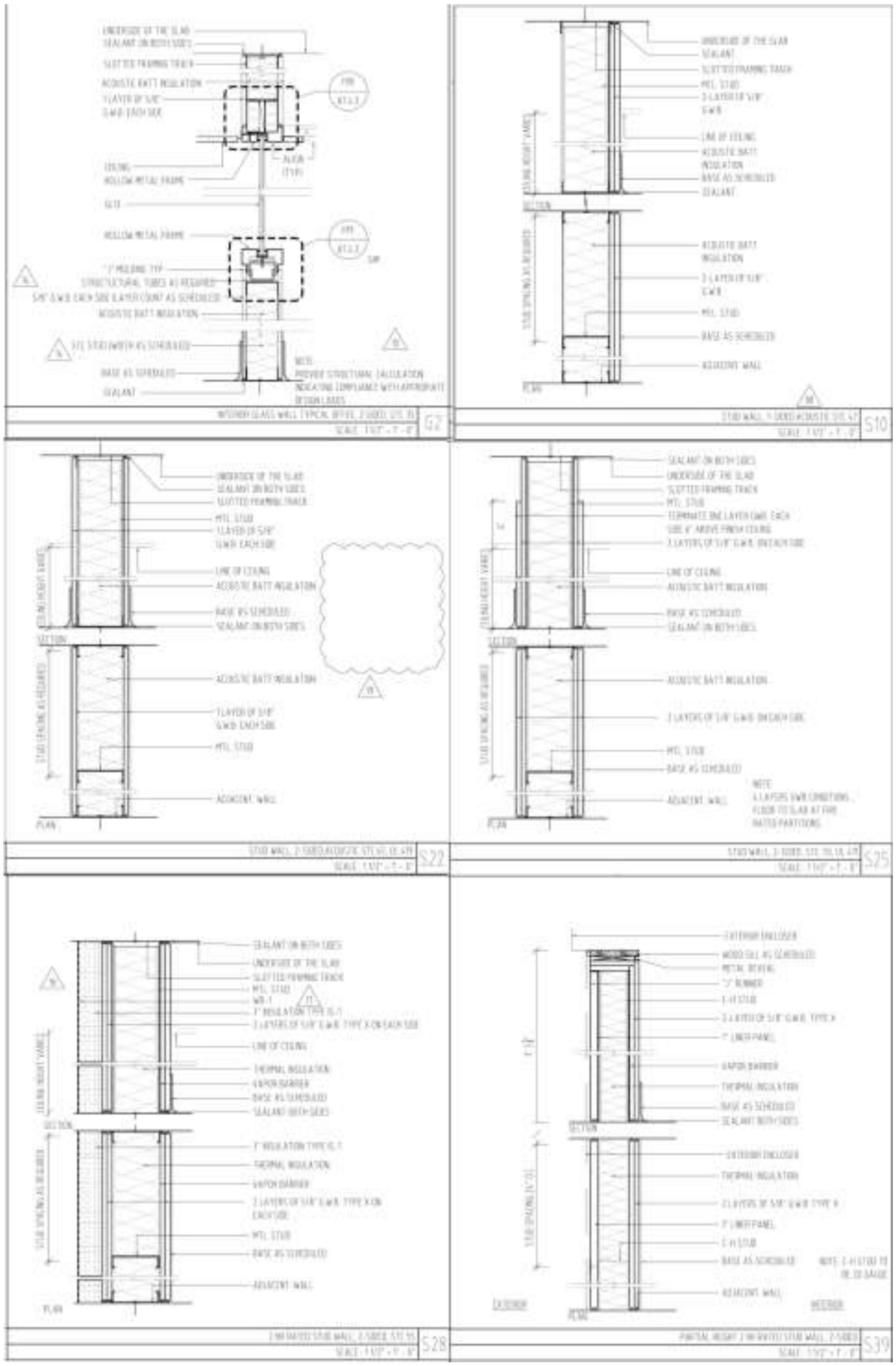

***Figure A**:* Wall Types in Tech 1 Spaces

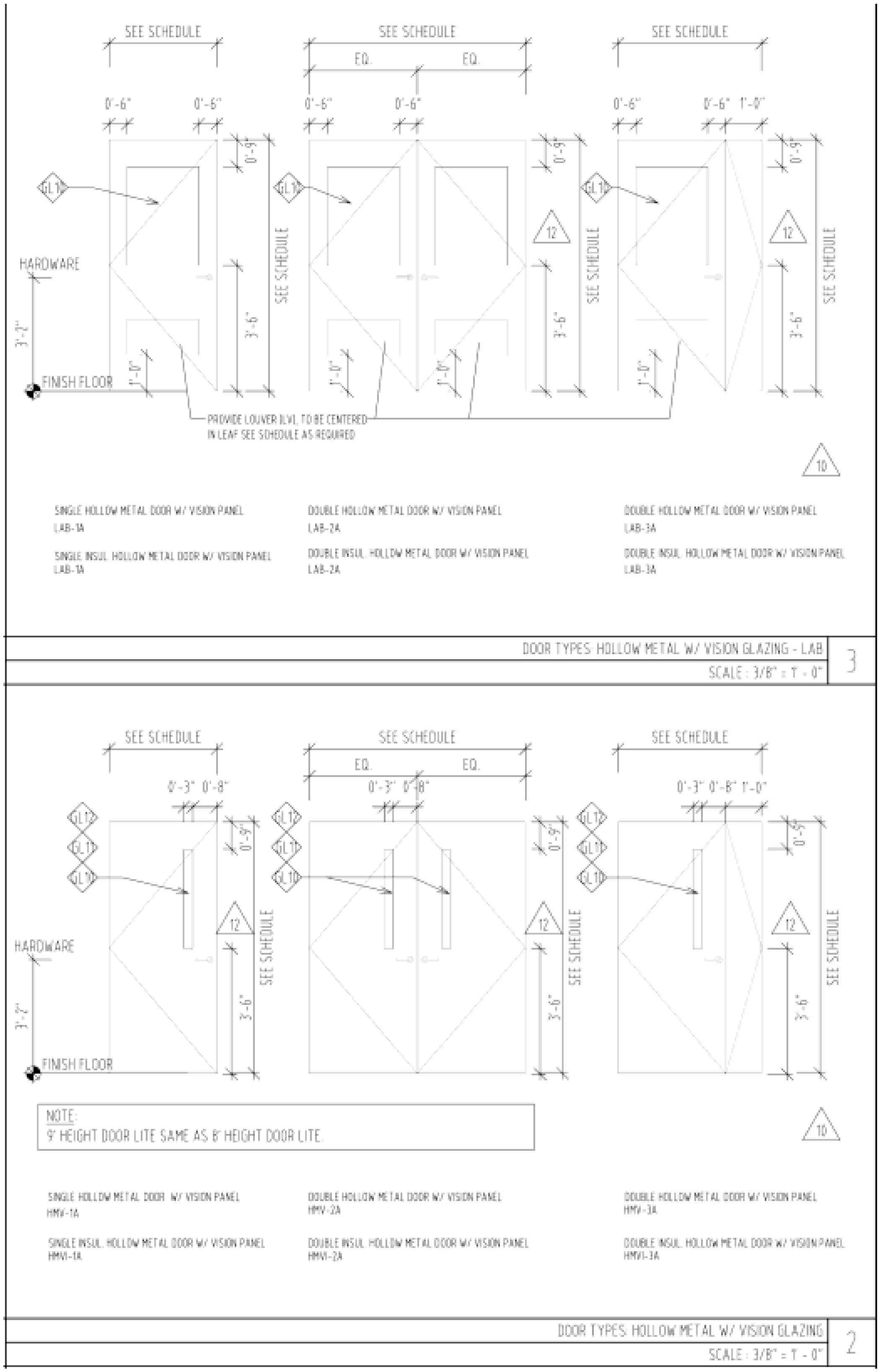

Figure B: Door Types in Tech 1 Spaces

ASHRAE 90.1-2007

TABLE 9.6.1 Lighting Power Densities Using the Space-by-Space Method

Common Space Types[a]	LPD, W/ft^2	Building-Specific Space Types	LPD, W/ft^2
Office—Enclosed	1.1	Gymnasium/Exercise Center	
Office—Open Plan	1.1	Playing Area	1.4
Conference/Meeting/Multipurpose	1.3	Exercise Area	0.9
Classroom/Lecture/Training	1.4	Courthouse/Police Station/Penitentiary	
For Penitentiary	1.3	Courtroom	1.9
Lobby	1.3	Confinement Cells	0.9
For Hotel	1.1	Judges' Chambers	1.3
For Performing Arts Theater	3.3	Fire Stations	
For Motion Picture Theater	1.1	Engine Room	0.8
Audience/Seating Area	0.9	Sleeping Quarters	0.3
For Gymnasium	0.4	Post Office—Sorting Area	1.2
For Exercise Center	0.3	Convention Center—Exhibit Space	1.3
For Convention Center	0.7	Library	
For Penitentiary	0.7	Card File and Cataloging	1.1
For Religious Buildings	1.7	Stacks	1.7
For Sports Arena	0.4	Reading Area	1.2
For Performing Arts Theater	2.6	Hospital	
For Motion Picture Theater	1.2	Emergency	2.7
For Transportation	0.5	Recovery	0.8
Atrium—First Three Floors	0.6	Nurses' Station	1.0
Atrium—Each Additional Floor	0.2	Exam/Treatment	1.5
Lounge/Recreation	1.2	Pharmacy	1.2
For Hospital	0.8	Patient Room	0.7
Dining Area	0.9	Operating Room	2.2
For Penitentiary	1.3	Nursery	0.6
For Hotel	1.3	Medical Supply	1.4
For Motel	1.2	Physical Therapy	0.9
For Bar Lounge/Leisure Dining	1.4	Radiology	0.4
For Family Dining	2.1	Laundry—Washing	0.6
Food Preparation	1.2	Automotive—Service/Repair	0.7
Laboratory	1.4	Manufacturing	
Restrooms	0.9	Low Bay (<25 ft Floor to Ceiling Height)	1.2
Dressing/Locker/Fitting Room	0.6	High Bay (≥25 ft Floor to Ceiling Height)	1.7
Corridor/Transition	0.5	Detailed Manufacturing	2.1
For Hospital	1.0	Equipment Room	1.2
For Manufacturing Facility	0.5	Control Room	0.5
Stairs—Active	0.6	Hotel/Motel Guest Rooms	1.1
Active Storage	0.8	Dormitory—Living Quarters	1.1
For Hospital	0.9	Museum	
Inactive Storage	0.3	General Exhibition	1.0
For Museum	0.8	Restoration	1.7
Electrical/Mechanical	1.5	Bank/Office—Banking Activity Area	1.5

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TABLE 9.6.1 Lighting Power Densities Using the Space-by-Space Method *(continued)*

Common Space Types[a]	LPD, W/ft²	Building-Specific Space Types	LPD, W/ft²
Workshop	1.9	Religious Buildings	
Sales Area [for accent lighting, see Section 9.6.2(b)]	1.7	Worship Pulpit, Choir	2.4
		Fellowship Hall	0.9
		Retail	
		Sales Area [for accent lighting, see Section 9.6.3(c)]	1.7
		Mall Concourse	1.7
		Sports Arena	
		Ring Sports Area	2.7
		Court Sports Area	2.3
		Indoor Playing Field Area	1.4
		Warehouse	
		Fine Material Storage	1.4
		Medium/Bulky Material Storage	0.9
		Parking Garage—Garage Area	0.2
		Transportation	
		Airport—Concourse	0.6
		Air/Train/Bus—Baggage Area	1.0
		Terminal—Ticket Counter	1.5

[a] In cases where both a common space type and a building-specific type are listed, the building specific space type shall apply.

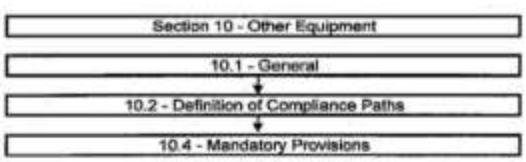
Retail Area 4 = the floor area used for the sale of jewelry, crystal, and china.

Exception: Other merchandise categories may be included in Retail Areas 2 through 4 above, provided that justification documenting the need for additional lighting power based on visual inspection, contrast, or other critical display is approved by the *authority having jurisdiction.*

9.7 Submittals (Not Used)

9.8 Product Information (Not Used)

10. OTHER EQUIPMENT



10.1 General

10.1.1 Scope. This section applies only to the equipment described below.

10.1.1.1 New Buildings. Other equipment installed in new buildings shall comply with the requirements of this section.

10.1.1.2 Additions to Existing Buildings. Other equipment installed in *additions* to *existing buildings* shall comply with the requirements of this section.

10.1.1.3 Alterations to Existing Buildings

10.1.1.3.1 *Alterations* to other building service equipment or systems shall comply with the requirements of this section applicable to those specific portions of the building and its systems that are being altered.

10.1.1.3.2 Any new equipment subject to the requirements of this section that is installed in conjunction with the *alterations*, as a direct replacement of existing equipment or control devices, shall comply with the specific requirements applicable to that equipment or control devices.

Exception: Compliance shall not be required for the relocation or reuse of existing equipment.

10.2 Compliance Path(s)

10.2.1 Compliance with Section 10 shall be achieved by meeting all requirements of Section 10.1, General; Section 10.4, Mandatory Provisions; and Section 10.8, Product Information.

10.2.2 Projects using the Energy Cost Budget Method (Section 11 of this standard) must comply with Section 10.4, the mandatory provisions of this section, as a portion of that compliance path.

10.3 Simplified/Small Building Option (Not Used)

10.4 Mandatory Provisions

10.4.1 Electric Motors. Electric motors shall comply with the requirements of the Energy Policy Act of 1992 where applicable, as shown in Table 10.8. Motors that are not included in the scope of the Energy Policy Act of 1992 have no performance requirements in this section.

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in enclosures that isolate ballast vibrations, or electronic ballasts.

ILLUMINANCE SELECTION

In 1979, the IESNA established an illuminance selection procedure, which was published in the 6th, 7th, and 8th editions of its *Lighting Handbook*. The philosophy of that procedure was to enable the lighting designer to select illuminances based on a knowledge of space and occupant characteristics as well as the task and worker characteristics.

The philosophy of that procedure has been embraced again in this edition, but the procedure has been modified and simplified to place visual performance and therefore illuminance selection more in balance with the other important lighting design criteria presented in this chapter and discussed throughout this edition of the *IESNA Lighting Handbook*. Specifically, the recommended illuminances provided in the Design Guide are based on the Society's judgment of best practice for "typical" applications. Every situation is unique so, naturally, typical conditions may not be appropriate for a specific application. As a professional, the lighting designer should have a better understanding of the particular space and the needs of the occupants and clients than what can be presented in a recommended illuminance value for a typical space.

Illuminance Recommendations

In 1979, the IESNA established nine illuminance categories, "A," the lowest set of recommended illuminances, through "I," the highest set. Each of the nine categories had general descriptions of the visual task, irrespective of the application. Generally, the same approach has been employed in this edition of the *IESNA Lighting Handbook* to help lighting designers establish the best task illuminance. However, four important modifications have been adopted.

- The recommended illuminances are no longer provided without reference to a specific application. Every application in the Design Guide has a specific recommended illuminance (horizontal, vertical, or both) representing best practice for a typical application.
- The nine illuminance selection categories established earlier by the IESNA have been reduced to seven categories and organized into three sets of visual tasks (orientation and simple, common, and special). These groupings provide additional clarity to the category descriptions (Figure 10-9).
- Additional precision has been given to the task descriptions in each category. In the previous three editions it was impossible for the lighting designer to unambiguously ascertain what constituted, for example, "low contrast" or "small size." Specific ranges of contrast and size have been established for this edition (Figures 10-10 and 10-11).
- Recommended illuminances increase roughly logarithmically with increasing task difficulty by combined changes in task contrast and task size, as defined in Figure 10-10. These recommendations are guided by both the scientific literature and practical experience.

Figure 10-9. Determination of Illuminance Categories*

Orientation and simple visual tasks. Visual performance is largely unimportant. These tasks are found in public spaces where reading and visual inspection are only occasionally performed. Higher levels are recommended for tasks where visual performance is occasionally important.

A	Public spaces	30 lx (3 fc)
B	Simple orientation for short visits	50 lx (5 fc)
C	Working spaces where simple visual tasks are performed	100 lx (10 fc)

Common visual tasks. Visual performance is important. These tasks are found in commercial, industrial and residential applications. Recommended illuminance levels differ because of the characteristics of the visual task being illuminated. Higher levels are recommended for visual tasks with critical elements of low contrast or small size.

D	Performance of visual tasks of high contrast and large size	300 lx (30 fc)
E	Performance of visual tasks of high contrast and small size, or visual tasks of low contrast and large size	500 lx (50 fc)
F	Performance of visual tasks of low contrast and small size	1000 lx (100 fc)

Special visual tasks. Visual performance is of critical importance. These tasks are very specialized, including those with very small or very low contrast critical elements. Recommended illuminance levels should be achieved with supplementary task lighting. Higher recommended levels are often achieved by moving the light source closer to the task.

G	Performance of visual tasks near threshold	3000 to 10,000 lx (300 to 1000 fc)

* Expected accuracy in illuminance calculations are given in Chapter 9, Lighting Calculations. To account for both uncertainty in photometric measurements and uncertainty in space reflections, measured illuminances should be with ± 10% of the recommended value. It should be noted, however, that the final illuminance may deviate from these recommended values due to other lighting design criteria.

High illuminances can partially compensate for small size and low contrast to maintain high levels of visual performance. Changes in visual performance as a function of task contrast and size, background reflectance, and observer age can be calculated precisely.[15] For well-controlled situations, this procedure can be a useful predictive tool. However, performance at a visual task depends on many uncontrolled vi-

IESNA Handbook Illuminance Categories

Acoustical Aspects. The acoustical criteria for open-plan offices are often quite stringent. Of special concern is the acoustical privacy between workstations. In closed office spaces this is provided by permanent walls, but in their absence, the ceiling takes on increased importance along with the space dividers. Luminaires, either recessed or surface mounted, can have an adverse effect on acoustical absorption. Lensed luminaires can reflect sound to adjacent workstations, whereas louvered units break up the reflected sound. To ensure a completely satisfactory open-plan installation, the designer should work with an acoustical consultant.

Private Offices

A private office is generally a fairly small space (8 to 12 m^2) with floor-to-ceiling partitions and one occupant. Ceiling-mounted direct luminaires are typical. Usually luminaires outside the private office cannot be seen by the occupant, so the luminaire brightness may be less important than it is for larger spaces. However, if the partition walls are glazed or contain clerestory windows, overhead lighting within the private office may affect those outside and vice versa. In this case, the overhead lighting should be treated as in open-plan areas.

As in open-plan offices, task lighting, combined with low-level general illumination, can be used for private offices. Because the wall area of a private office is large relative to the room size, there is opportunity for wall lighting to provide all or part of the general lighting; the result is often more pleasing in appearance than lighting from ceiling sources alone. Wall washing with individual luminaires or continuous linear sources produces a more open, brighter appearance. Highlighting features such as artwork or creating patterns of brightness on the walls also lend variety and interest.

For the best lighting layout, the furniture arrangement should be determined before the lighting is planned. This allows for specific placement of luminaires so as not to cause veiling reflections. This is rarely possible in a private office, so alternatives should be considered. These include indirect lighting from wall-mounted or ceiling-suspended luminaires, a combination of indirect luminaires and direct lighting, wall coves to provide both wall luminance and task illumination, and direct-indirect illumination from suspended or wall-mounted luminaires.

Downlighting should not be used to provide task illumination. The point source nature of these types of luminaires is likely to cause harsh hand shadows on the task. Additionally, if these luminaires are placed in the offending zone, reflected glare or veiling reflections can occur. Downlighting may be appropriate for wall washing or accent lighting, however.

Conference Rooms

Visual tasks in conference rooms range from casual to difficult. Direct glare and modeling of faces or objects as well as design composition, style, and image are the key issues for the lighting design for meetings. See Chapter 10, Quality of the Visual Environment. Two or more lighting systems should be planned to provide flexibility for this range:

1. A general lighting system in which the control of illuminance is provided by switches or dimmers.
2. A supplementary lighting system consisting of downlighting with dimmer control for slide projection and other low-level illumination requirements. Due to improved technology and the reduced cost of electronic dimming systems for fluorescent lamps, it is sometimes effective to incorporate dimming into the general fluorescent system, thus eliminating the need for a second system.
3. A perimeter or wall-wash lighting system controlled with dimmers for better visual appeal and for wall-mounted presentations.

Video Conference Lighting

Video conference lighting serves two purposes: to illuminate people working and interacting with each other, as in any conference room, and to illuminate people interacting with other people at remote locations, via video displays. These two requirements do not always complement each other. Lighting that is designed for maximum visual comfort and minimal glare does not always lend itself well to the lighting requirements for high-quality camera images.

Lighting for video conferencing has its roots in photographic and television lighting, where most of the fundamental principles and techniques for camera lighting apply. Camera lighting consists of key light, back light, and fill light. Key light creates dimensionality and a modeling effect for the subjects of the scene. Back light helps to outline the subjects, creating depth of field and heightening the sense of drama. Fill light provides general illumination, reduces harshness, and softens shadows. Both key and back light are task-specific, focused light aimed at the main subjects of the scene, whereas fill light can be regarded as ambient and diffused light.

Since video conference room lighting should create a normal conferencing setting without having the feeling of being on stage or under the spotlight, it is desirable not to have dramatic lighting for video conferencing. Practical implementation can also be achieved with two different layers of lighting: one with totally indirect luminaires for fill light, and the other with totally direct luminaires to provide key and back light. One benefit of using two separate lighting systems is that dimming can be separately applied to each lighting layer, creating a flexible lighting design that is more accommodating to individual preferences and to the varying functions of the conference room.

Typically, illuminances of 500 lx (50 fc) are adequate for occupants and for most modern video cameras. For more

IESNA Handbook Chapter 11: Lighting for Office Buildings information on meeting room lighting and television lighting, see Chapter 15, Theatre, Television, and Photographic Lighting.

Drafting and Graphic Production Rooms

Visual requirements for drafting demand high-quality illumination, since discrimination of fine detail is frequently required for extended periods of time. Significant graduation of shadows from drawing equipment and hands reduces visibility and productivity. Lighting systems that avoid reflected glare, veiling reflections, and task shadows are very important in providing maximum visibility. Indirect, semidirect, or other forms of overall ceiling lighting minimize shadows. When ceiling heights or energy constraints do not permit the use of these systems, direct lighting systems can be applied where the work surface is illuminated from both sides. In such a system, the absence of any luminaire in the offending zone also minimizes veiling reflections and reflected glare. Supplementary lighting equipment with user-adjustable support stems may be attached to the working surfaces, allowing the worker to position the light for critical task requirements or to overcome shadows and reflections. Some lighting systems are attached to drafting machines so that the light moves with the task. The requirements for computer-aided drafting (CAD) are very different. They are similar to but often more demanding than those for VDT tasks, because of the use of dark color monitors and very fine detailing and line weight (see the section "Offices with Video Display Terminals" in this chapter.)

Reception Areas

Reception areas are designed for people who are waiting for their appointments and, while waiting, reading or conversing with others. The lighting should be restful and yet provide enough illumination for reading.

One way to provide a restful atmosphere without direct glare is by illuminating one or more of the walls. Another way is to light the ceiling and part of the walls. Accent lighting for pictures or for a piece of sculpture enlivens the appearance of the room. If there is a receptionist located in the area, the ambient illumination may need to be augmented, depending on the visual tasks involved. Care should also be taken to illuminate the receptionist's face, so as to make this person look approachable, and also to eliminate harsh shadows caused by the downlights directly overhead. Task lighting can be provided for people waiting in the reception area.

Files

Files are primarily vertical work surfaces. In active filing areas, the work is likely to be long and visually difficult. Illumination should be directed onto the opened file drawers to minimize shadowing within the drawer. Where files are located in a general office environment and vertical illumination may also cause glare, consideration should be given to local illumination at the files, with individual manual or automatic switching located nearby.

Restrooms

Uniform illumination is not required in restrooms. Luminaires should provide light in the vicinity of the mirrors to illuminate the face. Other luminaires should illuminate bathroom fixtures and stalls and should be located so that partitions do not cast shadows on the plumbing or floors of the stalls. High illuminances in these areas also have a tendency to encourage cleanliness.

Public Areas

Public areas in a building include entrance and elevator or escalator lobbies, corridors, and stairways. Since many people move through these areas, the appearance of the space is very important, but so are safety requirements and the brightness balance with respect to adjacent areas. Public areas must remain illuminated for long periods, if not continuously. Therefore, serious consideration should be given to low-power lighting systems. Since many public areas are egress areas, an auxiliary lighting system is required to cope with power outages and system failures. These auxiliary systems can also serve as security lighting.

Entrance Lobbies

First impressions of office buildings are often perceived in entrance lobbies (Figure 11-15). The lighting should complement the architecture and provide for safe transition from the exterior to the interior. Consideration must be given to adaptation by the visual system from bright daylight conditions to darker interiors, or vice versa.

Perhaps the most important element in a lobby is the walls. Some may be of glass and some of opaque materials. Walls, if they are of high reflectance, can be illuminated, and the reflected light can provide all of the illumination for the lobby to provide orientation for people moving through it. If specular materials are used, unwanted reflections from luminaires must be considered. Grazing light from luminaires close to specular surfaces will minimize visible reflections.

If the lobby is enclosed with glass, the interior walls need to be at a higher brightness during the day in order to be seen from outside against the high daylight brightness. At night, a much lower brightness is required. The variable brightness also makes it easier for eyes to adapt to the ambient conditions when entering or leaving a building. For these reasons, the lobby lighting should incorporate dimming or switching controls. Since surfaces have a profound effect on the interaction of light and the space, the designer should work with the architect to choose building materials and lighting systems that work together to achieve the desired appearance from different perspectives and at different times.

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Figure 11-15. The main lobby of a building should provide a good impression. Materials in lobbies are often of high reflectance. The lighting should enhance the beauty of the building materials and at the same time minimize visible reflections.

Corridors

Corridor illumination on the floor should be at least one-fifth the illuminance of the floor in adjacent areas. This illuminance is both safe and energy efficient and does not require major visual adaptation upon entering and leaving the corridor.

Wall finish reflectances should equal or exceed those in adjacent areas. Linear luminaires oriented crosswise to the corridor generally make the narrow space appear wider. Continuous linear luminaires located adjacent to the side walls provide high wall brightness and can give a feeling of spaciousness. Corridors, which are paths of egress, must be provided with emergency lighting.

Elevator Lobbies

These are classified as casual seeing areas, so high-luminance differences are acceptable. Relatively high illuminance should be provided at the elevator threshold to call attention to possible differences in elevation between the elevator cab and the floor.

Elevators

Brightnesses approximately equal to those provided in the building corridors should be provided in elevators. Elevators are small confined spaces often shared by strangers, so the lighting should help people feel comfortable. Bright ceilings and walls can give a feeling of increased size and will also indirectly light people's faces. The lighting in an elevator should always be connected to the building's emergency power supply to help alleviate distress in the event of an elevator power failure or malfunction.

Stairways

The stair treads should be well illuminated, and the luminaires should be located to avoid glare and shadows cast by occupants onto the stairs. Luminaires should be easy to maintain because ladders are difficult to use in stairways. Emergency lighting should be provided in all public stairways. Although the lighting requirements are the same for all stairways, the lighting design solutions may be different.

OFFICES WITH VIDEO DISPLAY TERMINALS

The VDT is a major element in today's office and presents the design team with special problems. In creating a successful lighting design, direct and reflected glare must be controlled, as must the luminances in the field of view.

The VDT screen tilt is important; angles range from ver-

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Figure 13-10. A circular design element is used in a number of ways in this intimate restaurant: in the concentric circles in the ceiling, in the circular cove lighting, and in the circular waiting area that can be set off from the dining area by draperies. Downlights are aimed to illuminate table tops and provide general lighting.

Figure 13-11. This hotel restaurant has a a cheerful interior with a moderate illuminance level. Pendant luminaires delineate the section of booths.

nances (500 to 1000 lx [50 to 100 fc]) and uniform distribution can be used to suggest a feeling of economy and efficiency.

Food Courts

Food courts are designed to keep shoppers in the mall. If food is available in an inviting setting, there is less likelihood of people going home or off-site during peak meal hours.

Proper color rendering is critical, to complement the appearance of the food and the patrons. Although walk-up fast food counters may present a less sophisticated image than fine restaurants, the lighting should still make a positive contribution to the experience of being seen in a public space.

If lamp life and accessibility are not critical issues and directional light sources are required, incandescent and tungsten halogen reflector lamps are often considered. However, a variety of luminaires utilizing compact metal halide and color-improved high-pressure sodium lamps can also provide directional light distributions and good color rendition, along with longer lamp life and lower energy use.

For more diffuse lighting effects, compact fluorescent, linear fluorescent, and metal halide lamps are usually considered. These long-life light sources provide good to high color rendering capabilities, and they are available in a variety of correlated color temperatures. Typical applications include both direct and indirect lighting.

Recognizing that tables, chairs, trash receptacles, and other floor furniture can complicate maintenance accessibility in a food court, open luminaires with screw-based lamps can simplify relamping procedures. Although line-voltage incandescent and tungsten-halogen traditionally fulfilled this need, metal halide screw-based lamps are now available in a variety of versions for "open" luminaires.

In addition to line-voltage sources, low-voltage incandescent and tungsten halogen lamps are frequently used to highlight planters, fountains, and other special features. However, luminaires designed for compact metal halide lamps, reflector-style metal halide lamps, and color-improved high-pressure sodium lamps can also provide precise directional beam control, with longer life and lower energy use.

Depending on the demographics of the mall's patrons and the quality of the food vendors, the illuminance levels might range from relatively high values that stimulate fast turnover and frequent cleanup (100 lx [10 fc] or higher) to fairly subdued levels that encourage shoppers to linger and relax (50 to 100 lx [5 to 10 fc]). Selected illuminance levels should also account for the potential congestion that can occur in circulation aisles as peak-hour patrons negotiate their way past tables and chairs, while balancing loaded trays.

With the food vendors' signs, lighted graphics, and front-counter lighting, it is common for the tenant areas to contribute to the illumination at the adjacent food court walkways. However, as in the concourse, the designer of the food court rarely has direct control over the tenant lighting and its resultant contribution to the public space. Therefore, while it is important to consider anticipated conditions at the service counters, the food court lighting should be capable of providing appropriate illuminance levels independently of those same conditions (Figure 13-12).

Just as the selected illuminance levels and resulting luminance ratios in the concourse must strike an appropriate bal-

IESNA Handbook Chapter 13: Hospitality Facility Lighting

Figure 13-12. Whimsical signage delineates the food court of an upscale mall. A variety of light sources contributes to the cheerfulness of the place, including neon, fluorescent, and metal halide. Daylighting is incorporated through a skylight and window walls.

ance with the retail shop windows, the lighting of the food court must achieve a similar balance with the counter areas of the food vendors. A certain level of contrast is desirable to focus attention on the visual excitement of each tenant's graphics. However, an atmosphere of high contrast that might be appropriate in a bustling regional mall may be inappropriate in a more sophisticated fashion center.

Cleanup lighting is always an issue, even if the composition of the food court leans more towards fine dining than towards fast food. Typical recommended illuminance levels for cleaning are 100 to 200 lx (10 to 20 fc) averages maintained.

During normal hours the main lighting system must facilitate the level of clean-up activity that is appropriate for the given atmosphere, time of day, and service methods. After business hours, it is possible to rely on a secondary system of cleanup lights or a control system that allows a portion of the main lighting system to provide the necessary illumination. If dedicated cleanup lights are used, color rendering is not important.

Kitchen and Food Preparation Areas

Well-designed lighting helps to create a bright, hygienic atmosphere in a kitchen and, by revealing dirt and the presence of debris, can stimulate good housekeeping (Figure 13-13). Food preparation involves peeling, slicing, dicing, and cutting operations, both by machine and by hand. These are obviously hazardous, and lighting for safety must be a strong consideration.

Good lighting can reduce accidents, reveal spills that make floors slippery, and emphasize hazardous areas. In kitchen and associated support areas there is a need to eliminate shadows and to provide illumination on both vertical and horizontal surfaces. While kitchens contain difficult and demanding tasks that may require relatively high illuminances, luminaires should be placed and shielded so as not to create glare into adjacent intimate dining areas when kitchen doors are opened. This is particularly important when the adjacent dining area has lower light levels. Color rendering is important in food preparation and inspection areas.

Figure 13-13. This university food service kitchen has a bright, hygienic appearance with light levels high enough to accomplish the variety of food preparation and clean-up tasks that are performed in a kitchen.

Visibility can be reduced by large brightness variations in the visual field. Direct and reflected glare can be significant obstacles to employee comfort, productivity, and safety; therefore, exposed lamps in direct luminaires should not be used. In most food preparation areas, gasketed, damp-labeled luminaires are preferred. This allows for easy cleaning and prevents dirt and grease from entering the luminaires. Although glare can be controlled in direct luminaires by effective shielding of the lamps, indirect or direct-indirect lighting is preferable because it turns the entire ceiling into a large, low-brightness area source.

Light-colored walls further diffuse the general lighting, reducing shadows. Because vertical surfaces of equipment and furnishings typically occupy a significant portion of the visual field, especially in kitchens, light finishes are recommended for these surfaces.

IESNA Handbook Chapter 13: Hospitality Facility Lighting

IESNA Handbook Lighting Design Guide

IESNA Lighting Design Guide Interior-5

I. INTERIOR LOCATIONS AND TASKS — Very important / Important / Somewhat important / Blank = Not important or not applicable

Design Issues: Appearance of Space and Luminaires; Color Appearance (and Color Contrast); Daylighting Integration and Control; Direct Glare; Flicker (and Strobe); Light Distribution on Surfaces; Light Distribution on Task Plane (Uniformity); Luminances of Room Surfaces; Modeling of Faces or Objects; Point(s) of Interest; Reflected Glare; Shadows; Source/Task/Eye Geometry; Sparkle/Desirable Reflected Highlights; Surface Characteristics; System Control and Flexibility; Special Considerations

Locations and Tasks	Notes on Special Considerations	Illuminance (Horizontal) Category or Value (lux)	Illuminance (Vertical) Category or Value (lux)	Notes on Illuminance - see end of section	Reference Chapter(s)
Conference Rooms					Ch. 11
Meeting		D	B		
Critical seeing (refer to task)					
Video conference	(1)	E	D		
Educational Facilities					Ch. 12
Corridors			C		
Classrooms					
General (see Reading)					
Art rooms		E	D		
Drafting (see Drafting/Graphic Arts)					
Home economics (see Residences)					
Science laboratories		E	D		
Lecture halls					
Audience (see Reading)					
Demonstration		F	E		
Music rooms (see Reading)					
Shops (see Section II, Industrial)					
Sight saving rooms		F	E		
Study halls (see Reading)					
Typing (see Reading)					
Gymnasiums					Ch. 20
Basketball		F	D		
Other sports (See Section IV, Sports)					
Social events		B	A		
Outdoor sports facilities (see Section IV, Sports)					Ch. 20
Cafeterias (see Food Service Facilities)					Ch. 13
Dormitories (see Residences)					Ch. 18
Food Service Facilities					Ch. 13
(If equipment locations are known, see Residences-Kitchens)					
Butcher shop		E	C		
Cashier		D	A		
Cleaning		C			
Dining		C	A		
Food displays		E		(8)	
Food storage					
Nonrefrigerated		B	A		
Refrigerated		B	A		
Galley		E	C		
Kitchen		E	A		
Pantry		D	A		
Refuse area		C			
Sculleries		E	C		
Thaw room		D	A		

IESNA Lighting Design Guide

Interior-5

I. INTERIOR
LOCATIONS AND TASKS

Very important | Important | Somewhat important | Blank = Not important or not applicable

Locations and Tasks	Design Issues (Appearance of Space and Luminaires; Color Appearance (and Color Contrast); Daylighting Integration and Control; Direct Glare; Flicker (and Strobe); Light Distribution on Surfaces; Light Distribution on Task Plane (Uniformity); Luminances of Room Surfaces; Modeling of Faces or Objects; Point(s) of Interest; Reflected Glare; Shadows; Source/Task/Eye Geometry; Sparkle/Desirable Reflected Highlights; Surface Characteristics; System Control and Flexibility; Special Considerations)	Notes on Special Considerations	Illuminance (Horizontal) Category or Value (lux)	Illuminance (Vertical) Category or Value (lux)	Notes on Illuminance - see end of section	Reference Chapter(s)
Food Courts		(9)	D	A		Ch. 13
Offices (13)						Ch. 11
Filing (see Reading)			E	C		
General and private offices (see Reading)						
Open plan office						
Intensive VDT use		(14,15)	D	B		
Open plan office						
Intermittent VDT use		(14,15)	E	B		
Private office			E	B		
Libraries (see Libraries)						
Lobbies, lounges, and reception areas			C	A		
Mail sorting			E	A		
Copy rooms			C	A		
Reading (16)						Ch. 11, 12
Copied tasks						
Microfiche reader			A	A		
Photograph, moderate detail			E			
Thermal copy, poor			F			
Photocopies			D			
Photocopies, 3rd generation			E			
Data processing tasks						
VDT screens			A	A		
Impact printer						
good ribbon			D			
2nd carbon and greater			E			
ink jet/laser printer			D			
keyboard reading			D			
Machine rooms						
Active operations			D			
Tape storage			D	B		
Machine area			C			
Equipment service			E	C		
Thermal print			E			
Handwritten tasks						
#2 pencil and softer leads			D			
#3 pencil			E			
#4 pencil and harder leads			F			
Ball-point pen			D			
Felt-tip pen			D			
Handwritten carbon copy			E			
White boards				B		
Chalk boards				E		
Printed tasks						
6-point type			E			
8- and 10-point type			D			
Glossy magazines			D			
Maps			E			
Newsprint			D			
Typed originals			D			
Telephone books			E			
Service Spaces (see Service Spaces in Section II, Industrial)						Ch. 11, 19
Stairways and corridors			B			
Elevators (see Elevators)						
Toilets and washrooms			B	A		

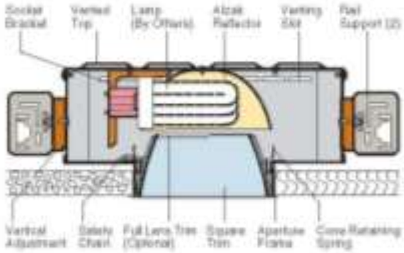
Fixture Cut Sheets

Lighting Fixture Cut Sheet Package

Pennsylvania State University

Millennium Science Complex
March 09, 2009

bpi



H8643 H23

Shallow Depth, Wide Beam Downlight
One 26-32-42W Triple Tube Compact Fluorescent
6" Square Parabolic Trim

Optics and Applications
The socket is mounted horizontally in an ellipsoidal primary reflector for wide distribution and reduced recess depth in shallow plenums. Use in low to medium height ceilings for corridors, entries and for general and area lighting.

Design Features
A steel housing protects and aligns reflectors and lamps. The socket and ballast will accept all triple tube wattages interchangeably. The square trim is stabilized by a proprietary steel web to prevent racking and is held to the ceiling by constant pressure springs. Maximum ceiling thickness 1½". Ballast and lamp service from below.

Finish
Housings and structural parts are painted matte black to suppress stray light leaks. Standard trims are anodized Softglow® clear. Special finishes, textures and colors are available, see below under Accessories.

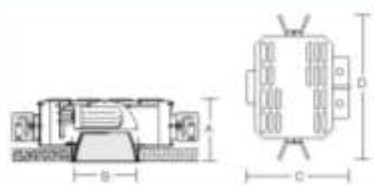
Trim Textures
Textured trims create a subtle new aperture appearance. Select among different embossed patterns to match the ambiance of the space being illuminated. Refer to Squares brochure for descriptive photos.

Ballasts
Fully electronic, microprocessor controlled with programmed start to assure rated lamp life. Input voltage ranges from 120V through 277V. Operates 26, 32 or 42W lamps interchangeably. Power factor .98, starting temperature 0°F (-18°C), THD<10%. Pre-heat start < 1.0 second. End of lamp life protection. Rated for > 50,000 starts.

General
Fixtures are pre-wired, UL and C-UL listed for eight wire 75°C branch circuit wiring. Union made IBEW. Luminaire Efficiency Rating (LER) data is in the photometric directory located in Section Z.

Accessories
R2 26" support rails.
R5 52" support rails.
SB Softglow black.
SG Softglow gold.
SH Softglow mocha.
SP Softglow graphite.
ST Softglow titanium.
SW Softglow wheat.
SY Softglow pewter.
SZ Softglow bronze.
BR Bright trim finish.
FR Frosting on lens.
F Fuse.
WT White trim flange.
WHT White complete trim.
BP Ball Peen texture.
CG Corrugated texture.
DS Distressed texture.
WV Woven texture.
LL Linear spread lens.
LP Large prism lens.
MP Microprism lens.
V347 347 volt ballast.
FC Four cell cross baffle.
DM Dimming ballast. Specify watts and volts.
EM Emergency power includes integral charger light and test switch visible through aperture. Battery operation for 90 minutes.
FLT6 Full lens trim, specify lens type, e.g. H8643-FLT6LL.
WRL Wattage restriction label, specify wattage.

Dimensions and Lamps



Number	A Depth	B Aperture	C Width	D Length	Lamps
H8643	6½" 165mm	6" sq. 153mm	13½" 343mm	19" 483mm	26-32-42W TripleTube compact fluorescent

Brightness

Number	Lamps	85°	75°	65°	55°	45°
H8643	32W T/E Osram/Syl	31	87	209	1221	10019
	32W PL-T Philips	37	108	218	8696	11729
	42W PL-T Philips	40	181	273	8857	19941
	42W T/E Osram/Syl	53	195	367	4046	17428

Data in footlamberts. Photometer readings, Maximum Brightness Method

Matching Square Units *
Vertical lamp fluorescent — Page H22
Low voltage — Pages H5, H6
PAR lamps — Pages H7, H8, H9
Directional — Page H9
Halogens, A lamps — Page H10
Tungsten halogen — Page H11
Metal halide — Pages H26, H27, H28
Wall washer — Page H57

* Click for link to pages in blue.

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DC-1

H23 H8643

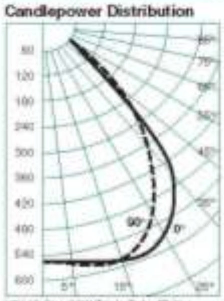
Performance Datachart

H8643 One 32W Philips Triple Tube Read Top Data
H8643 One 42W Philips Triple Tube Read Bottom Data

Single Unit Initial Footcandles, 30" Work Plane							Ceiling to Floor	Multiple Units Initial Footcandles, 30" Work Plane (Ceiling 80% Walls 50% Floor 20%; Spacing is Maximum Over Work Plane)			
Nadir	10°		20°		30°						
FC	FC	Diam	FC	Diam	FC	Diam		Spacing	RCR 1	RCR 3	RCR 6
19 29	19 27	2' 2'	16 21	4' 4'	10 15	6' 6'	8'	7' 6'	23 36	19 32	15 21
21 18	13 19	2' 2'	11 15	5' 5'	7 10	8' 8'	9'	9' 7'	16 27	14 23	11 15
10 16	10 14	3' 3'	9 11	6' 6'	5 7	9' 9'	10'	9' 8'	12 20	10 17	8 11
8 12	8 11	3' 3'	7 9	6' 6'	4 6	10' 10'	11'	10' 9'	10 16	8 14	6 9
6 10	6 8	3' 3'	5 7	7' 7'	3 4	11' 11'	12'	12' 10'	8 15	6 11	5 7

See notes 2, 3 and 4

Candlepower Distribution

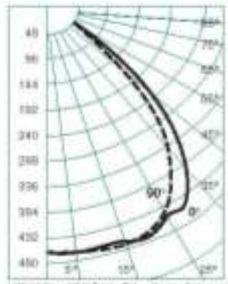


H8643 One 32W Triple Tube Philips
Eff. 38% S/M 0° 1.30 S/M 90° 1.14

Candelas

⊙	0° 2400*	90° 2400*
0	560	560
5	561	565
10	568	579
15	586	581
20	588	567
25	559	516
30	521	431
35	455	359
40	358	283
45	258	194
50	160	124
55	92	58
60	22	21
65	9	12
70	0	0
75	0	0
80	0	0
85	0	0
90	0	0

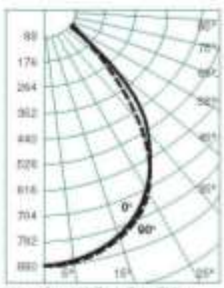
⊙ Vertical Angles
* Initial Lamp Lumens



H8643 One 32W Triple Tube Osram Sylvania
Eff. 33% S/M 0° 1.36 S/M 90° 1.24

⊙	0° 2400*	90° 2400*
0	457	457
5	456	460
10	464	470
15	469	476
20	475	479
25	440	452
30	457	399
35	396	337
40	318	266
45	239	175
50	136	99
55	52	34
60	13	14
65	8	9
70	6	7
75	0	0
80	0	0
85	0	0
90	0	0

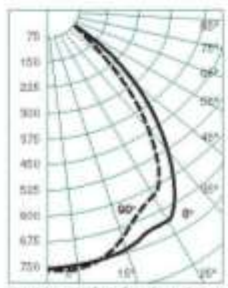
⊙ Vertical Angles
* Initial Lamp Lumens



H8643 One 42W Triple Tube Philips
Eff. 38% S/M 0° 1.07 S/M 90° 1.06

⊙	0° 3200*	90° 3200*
0	886	880
5	886	869
10	942	843
15	919	816
20	768	781
25	694	710
30	618	602
35	506	441
40	386	322
45	266	235
50	172	173
55	107	115
60	50	60
65	19	17
70	0	0
75	0	0
80	0	0
85	0	0
90	0	0

⊙ Vertical Angles
* Initial Lamp Lumens



H8643 One 42W Triple Tube Osram Sylvania
Eff. 35% S/M 0° 1.21 S/M 90° 1.13

⊙	0° 3200*	90° 3200*
0	757	757
5	756	761
10	751	741
15	746	704
20	725	647
25	716	625
30	632	569
35	529	454
40	408	315
45	298	194
50	185	128
55	102	61
60	40	36
65	10	15
70	0	0
75	0	0
80	0	0
85	0	0
90	0	0

⊙ Vertical Angles
* Initial Lamp Lumens

Notes

1. Satinglow* cone multipliers: Gold x .88, Wheat x .87, Pewter x .73, Mocha x .72, Graphite x .70, Titanium x .70, Bronze x .66.
2. Single unit Datachart pattern diameters are determined by the number of degrees from each side of nadir. Therefore a 20° diameter represents a total 40° pattern width at the work plane 30" above the floor. Footcandle values are at the edge of that diameter.
3. Datachart spacing is rounded off to the nearest foot.
4. Data by IES methods. Compact fluorescent data vary due to lamp lumen differences, power input, burning position, ambient temperature and ballast characteristics. A modification factor should be applied.
5. Brightness data from the Average Luminance Method are inaccurate for small aperture downlights. They are theoretical calculations derived for large surfaces such as troffers. For a complete discussion refer to section Z brochure Z1.

Coefficients of Utilization

Ceiling	80%				70%		50%		30%		0
Wall %	70	50	30	10	50	10	50	10	50	10	0
RCR	Zonal Cavity Method - Floor Reflectance 20%										
1	.43	.41	.40	.39	.41	.38	.39	.38	.38	.36	.35
2	.40	.39	.36	.35	.37	.34	.36	.34	.35	.33	.31
3	.38	.35	.33	.31	.34	.31	.33	.30	.32	.30	.29
4	.35	.32	.30	.29	.32	.29	.31	.27	.30	.27	.26
5	.33	.29	.27	.26	.29	.26	.28	.25	.28	.24	.24
6	.31	.27	.25	.23	.27	.23	.26	.22	.26	.22	.22
7	.29	.26	.23	.21	.26	.21	.24	.21	.24	.20	.20
8	.28	.25	.21	.19	.23	.19	.23	.19	.22	.19	.18
9	.26	.23	.19	.18	.22	.18	.21	.17	.21	.17	.17
10	.25	.20	.18	.16	.20	.16	.20	.16	.20	.16	.16

H8643 One 42W Philips
H8643 One 32W Philips x 1.00
H8643 One 42W Osram x .93
H8643 One 42W Osram x .96

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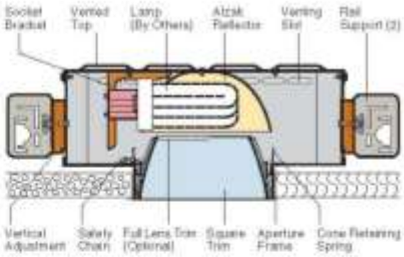

H8643

H23

Shallow Depth, Wide Beam Downlight
One 26-32-42W Triple Tube Compact Fluorescent
6" Square Parabolic Trim

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A steel housing protects and aligns reflectors and lamps. The socket and ballast will accept all triple tube wattages interchangeably. The square trim is stabilized by a proprietary steel web to prevent racking and is held to the ceiling by constant pressure springs. Maximum ceiling thickness 1½". Ballast and lamp service from below.

Finish
Housings and structural parts are painted matte black to suppress stray light leaks. Standard trims are anodized Softglow® clear. Special finishes, textures and colors are available, see below under Accessories.

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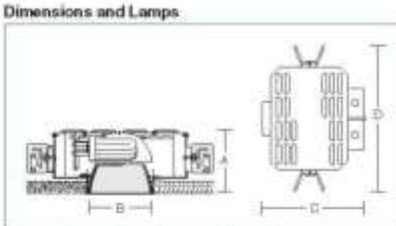
Fully electronic, microprocessor controlled with programmed start to assure rated lamp life. Input voltage ranges from 120V through 277V. Operates 26, 32 or 42W lamps interchangeably. Power factor .98, starting temperature 0°F (-18°C), THD<10%. Pre-heat start < 1.0 second. End of lamp life protection. Rated for > 50,000 starts.

General
Fixtures are pre-wired, UL and C-UL listed for eight wire 75°C branch circuit wiring. Union made IBEW. Luminaire Efficiency Rating (LER) data is in the photometric directory located in Section Z.

Dimensions and Lamps



Number	A Depth	B Aperture	C Width	D Length	Lamps
H8643	6½" 165mm	6" sq. 153mm	13½" 343mm	19" 483mm	26-32-42W Triple Tube compact fluorescent

Brightness

Number	Lamps	85°	75°	65°	55°	45°
H8643	32W T/E Osram/Syl	31	67	209	1221	10019
	32W PL-T Philips	37	108	218	6698	13728
	42W PL-T Philips	40	151	275	6867	18941
	42W T/E Osram/Syl	53	186	967	4564	17420

Data in footlamberts. Photometer readings. Maximum Brightness Method.

Matching Square Units *

Vertical lamp fluorescent	Page H22
Low voltage	Pages H5, H6
PAR lamps	Pages H7, H8, H9
Directional	Page H9
Halogena, A lamps	Page H10
Tungsten halogen	Page H11
Metal halide	Pages H26, H27, H28
Wall washer	Page H37

* Click for link to pages in blue.

Accessories
R2 26" support rails.
R5 52" support rails.
SB Softglow black.
SG Softglow gold.
SH Softglow mocha.
SP Softglow graphite.
ST Softglow titanium.
SW Softglow wheat.
SY Softglow pewter.
SZ Softglow bronze.
BR Bright trim finish.
FR Frosting on lens.
F Fuse.
EM Emergency power includes integral charger light and test switch visible through aperture. Battery operation for 90 minutes.
FLT6 Full lens trim, specify lens type, e.g. H8643-FLT6LL.
WRL Wattage restriction label, specify wattage.
WT White trim flange.
WHT White complete trim.
BP Ball Peen texture.
CG Corrugated texture.
DS Distressed texture.
WV Woven texture.
LL Linear spread lens.
LP Large prism lens.
MP Microprism lens.
V347 347 volt ballast.
FC Four cell cross baffle.
DM Dimming ballast.
Specify watts and volts.

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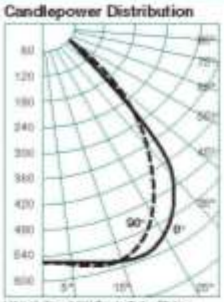
H23 H8643

Performance Datachart

Single Unit Initial Footcandles, 30" Work Plane							Ceiling to Floor	Multiple Units, Initial Footcandles, 30" Work Plane			
H8643 One 32W Philips Triple Tube Read Top Data H8643 One 42W Philips Triple Tube Read Bottom Data								Ceiling 80% Walls 50% Floor 20%			
Nadir	10°		20°		30°			Spacing is Maximum Over Work Plane			
FC	FC	Diam	FC	Diam	FC	Diam		Spacing	RCR 1	RCR 3	RCR 6
18 29	16 27	2' 2'	16 21	4' 4'	10 13	6' 6'	8'	7' 6'	23 38	18 32	15 21
21 18	13 19	2' 2'	11 15	5' 5'	7 10	8' 8'	9'	8' 7'	16 27	14 23	11 15
11 16	10 14	3' 3'	8 11	5' 6'	5 7	9' 9'	10'	9' 8'	12 20	10 17	8 11
8 12	9 11	3' 3'	7 9	6' 6'	4 6	10' 10'	11'	10' 9'	10 16	8 14	6 9
8 10	8 9	3' 3'	5 7	7' 7'	3 4	11' 11'	12'	12' 10'	8 13	8 11	5 7

See notes 2, 3 and 4

Candlepower Distribution

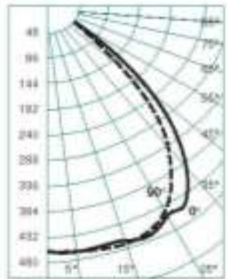


H8643 One 32W Triple Tube Philips
Eff. 38% S/M 0° 1.30 S/M 90° 1.14

Candelas

°	0° 2400*	90° 2400*
0	560	560
5	561	565
10	569	578
15	585	581
20	569	547
25	558	516
30	521	431
35	455	369
40	368	283
45	256	194
50	165	124
55	92	59
60	22	21
65	9	13
70	0	0
75	0	0
80	0	0
85	0	0
90	0	0

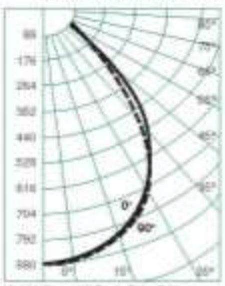
° Vertical Angles
* Initial Lamp Lumens



H8643 One 32W Triple Tube Osram Sylvania
Eff. 33% S/M 0° 1.36 S/M 90° 1.24

°	0° 2400*	90° 2400*
0	457	457
5	466	460
10	464	470
15	469	476
20	476	473
25	449	452
30	457	399
35	396	337
40	316	256
45	233	170
50	136	99
55	52	34
60	13	14
65	5	3
70	6	7
75	0	0
80	0	0
85	0	0
90	0	0

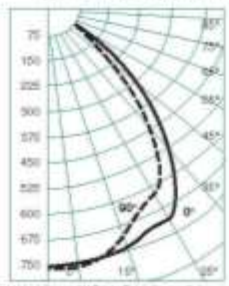
° Vertical angles
* Initial Lamp Lumens



H8643 One 42W Triple Tube Philips
Eff. 38% S/M 0° 1.07 S/M 90° 1.06

°	0° 3200*	90° 3200*
0	880	930
5	880	889
10	842	843
15	813	816
20	768	781
25	694	710
30	619	602
35	506	461
40	386	322
45	266	235
50	172	175
55	107	113
60	50	50
65	19	17
70	0	0
75	0	0
80	0	0
85	0	0
90	0	0

° Vertical Angles
* Initial Lamp Lumens



H8643 One 42W Triple Tube Osram Sylvania
Eff. 30% S/M 0° 1.21 S/M 90° 1.13

°	0° 3200*	90° 3200*
0	757	757
5	750	761
10	751	741
15	746	704
20	735	647
25	718	435
30	632	569
35	529	454
40	408	315
45	298	194
50	185	126
55	102	81
60	40	38
65	15	15
70	0	0
75	0	0
80	0	0
85	0	0
90	0	0

° Vertical Angles
* Initial Lamp Lumens

Notes

1. Softglow® cone multipliers: Gold x .89, Wheat x .87, Pewter x .79, Mocha x .75, Graphite x .70, Titanium x .70, Bronze x .48.
2. Single unit Datachart pattern diameters are determined by the number of degrees from each side of nadir. Therefore a 20° diameter represents a total 40° pattern width at the work plane 30" above the floor. Footcandle values are at the edge of that diameter.
3. Datachart spacing is rounded off to the nearest foot.
4. Data by IES methods. Compact fluorescent data vary due to lamp lumen differences, power input, burning position, ambient temperature and ballast characteristics. A modification factor should be applied.
5. Brightness data from the Average Luminance Method are inaccurate for small aperture downlights. They are theoretical calculations derived for large surfaces such as troffers. For a complete discussion refer to section Z brochure Z1.

Coefficients of Utilization

Ceiling	80%				70%		50%		30%		0
Wall %	70	50	30	10	50	10	50	10	50	10	0
RCR	Zonal Cavity Method - Floor Reflectance 20%										
1	.43	.41	.40	.39	.41	.39	.39	.38	.38	.36	.35
2	.40	.38	.36	.35	.37	.34	.36	.34	.35	.33	.31
3	.38	.35	.33	.31	.34	.31	.33	.30	.32	.30	.29
4	.35	.32	.30	.28	.32	.28	.31	.27	.30	.27	.26
5	.33	.28	.27	.25	.29	.25	.28	.25	.28	.24	.24
6	.31	.27	.25	.23	.27	.23	.26	.22	.26	.22	.22
7	.29	.25	.23	.21	.25	.21	.24	.21	.24	.20	.20
8	.26	.23	.21	.19	.23	.19	.23	.19	.22	.19	.18
9	.26	.22	.19	.18	.22	.18	.21	.17	.21	.17	.17
10	.25	.20	.18	.16	.20	.16	.20	.16	.20	.16	.16

H8643 One 42W Philips
H8643 One 32W Philips x 1.00
H8643 One 42W Osram x .93
H8643 One 42W Osram x .86

Kurt Versen Company, Westwood, New Jersey

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Lighting design
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PSU

DC-1A

FO FO™

DESCRIPTION

Low brightness 6" aperture downlight for use with 26W, 32W or 42W Triple Tube 4-pin compact fluorescent lamp. The lensed reflector provides superior shielding. Reflector trim eliminates brightness at higher angles. Standard features include low iridescent finish on all reflectors. Venting ensures maximum lamp life and lumen output. Open downlight, lens, and open wall wash trims are interchangeable within the same housing.

Catalog #		Type
Project		
Comments		Date
Prepared by		

SPECIFICATION FEATURES

A ... Reflector
Clear upper Alzak® reflector for maximum light output. Positive reflector mounting, without tools, pulls trim tight to ceiling. Lower spun parabolic reflector, .050 thick aluminum available in a variety of Alzak® finishes.

B ... Lens
Choice of tempered fresnel, prismatic, diffuse, or clear glass lenses or molded prismatic acrylic, opal diffuser or clear UV stabilized acrylic. Lens is fixed to lower reflector.

C ... Socket Connector
One piece die cast aluminum connection allows venting for maximum thermal performance.

D ... Housing Mounting Frame
One piece precision die cast aluminum 1-1/2" deep collar accommodates varying dimensions of ceiling materials.

E ... Universal Mounting Bracket
Accepts 1/2" EMT, C Channel, T bar fasteners, and bar hangers. Adjusts 5" vertically from above or below ceiling.

F ... Conduit Fittings
Die cast screw tight connectors.

G ... Junction Box
Listed for eight #12AWG (four in, four out) 90°C conductors feed through branch wiring. 1/2" and two 3/4" pry outs. Positioned to allow straight conduit runs. Access to junction box by removing reflector.

H ... Socket
4 pin GX24q 3/4 base with fatigue free stainless steel lamp spring ensures positive lamp retention.

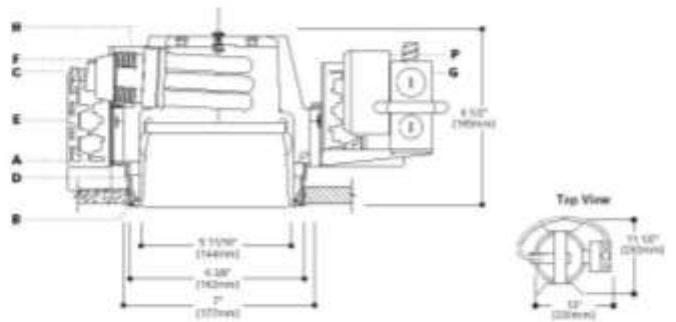
I ... Electronic Ballast
Electronic ballast provides full light output and rated lamp life. Provides flicker free and noise free operation and starting. End of lamp life protection is standard.

Labels
cULus listed. Wet label.

C6142 6181/80

26W, 32W, 42W TTT
Compact Fluorescent

6" LENSED DOWNLIGHT



ENERGY DATA
26W Triple 4-pin
Ballast: Electronic
[illegible]
Sound Rating: A
32W Triple 4-pin
Ballast: Electronic
[illegible]
Sound Rating: A
32W Triple 4-pin
Ballast: Dimming
[illegible]
Sound Rating: A
NOTES:
[illegible]

ORDERING INFORMATION

[illegible]

Housing
C6 - 6" Horizontal Lamp

Number of Lamps
1 - 1 Lamp

Wattage
42 - 26W, 32W, or 42W TTT Lamp

Ballast
[illegible]

Options
CP - Chicago Plenum
EM - Emergency Module with remote test switch

Trims
6181 - Lensed Downlight Self Flanged Reflector
6180 - [illegible]

Finish
[illegible]

Lens
[illegible]

Options
[illegible]

Accessories
[illegible]

COOPER Lighting
www.cooperlighting.com

Specifications and Dimensions subject to change without notice.
[illegible]

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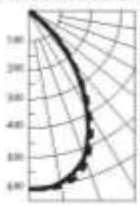
PSU

DC-4-d1

PHOTOMETRICS [illegible]

Candlepower Distribution



Test No. H22211
C6132 6180LI1
Specular Reflector with Prismatic Lens
Lamp=32W TTT
Lumens=2400
Spacing Criteria= 0°=1.1, 90°=1.1
Efficiency=38.0%

Candlepower

Deg.	CD 0°	90°
0	613	613
5	621	628
15	609	616
25	535	538
35	336	364
45	150	184
55	73	78
65	36	28
75	0	0
85	0	0
90	0	0

Average Luminance

Deg.	CD/SQ M 0°	90°
45	13675	15613
55	7798	8319
65	4340	3601
75	0	0
85	0	0

Cone of Light

Distance to Illuminated Plane	Initial Nadir Footcandles	Beam Diameter
5'6"	20	5'0"
6'9"	15	7'0"
8'0"	10	9'0"
10'0"	6	11'5"
12'0"	4	12'5"
14'0"	3	15'0"

Beam diameter is to 50% of maximum footcandles, rounded to the nearest half-foot.

Footcandle values are initial, apply appropriate light loss factors where necessary.

Lamp Multiplier
24W TTT=.79

Reflector Multiplier
Haze=.95
Straw=.[illegible]
Wheat=.[illegible]

EM Multiplier (In emergency mode)
EM=.27

Zonal Lumen Summary

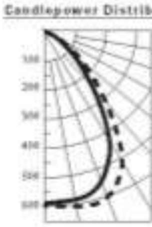
Zone	Lumens	%Lamp	%Luminaire
0-30	463	19.3	50.7
0-40	674	28.1	73.9
0-60	874	36.5	96.0
0-90	912	38.0	100.0
90-180	0	0.0	0.0
0-180	912	38.0	100.0

Coefficient of Utilization

rc	80%				70%			50%		30%		10%		0%
rw	70	50	30	10	50	30	10	50	10	50	10	50	10	0
RCR														
0	45	45	45	45	44	44	44	42	42	40	40	39	39	38
1	42	42	41	40	41	40	39	39	38	38	37	37	36	35
2	41	39	37	36	38	37	35	37	35	36	34	35	33	32
3	38	35	34	32	35	33	32	34	31	33	31	32	30	30
4	35	33	31	29	33	31	29	32	29	31	28	30	28	27
5	34	31	28	27	30	28	26	30	26	29	26	28	25	25
6	32	28	26	24	28	26	24	28	24	27	24	27	24	23
7	30	26	24	22	26	24	22	26	22	25	22	25	22	21
8	28	24	22	20	24	22	20	24	20	23	20	23	20	19
9	27	23	20	18	22	20	18	22	18	22	18	21	18	18
10	25	21	19	17	21	19	17	21	17	20	17	20	17	16

rc=Ceiling reflectance, rw=Wall reflectance, RCR=Room cavity ratio
CU Data Based on 20% Effective Floor Cavity Reflectance.

Candlepower Distribution



Test No. H22216
C6132 6180LI1
Specular Reflector with Prismatic Lens
Lamp=32W PLT
Lumens=2400
Spacing Criteria= 0°=1.1, 90°=1.2
Efficiency=39.8%

Candlepower

Deg.	CD 0°	90°
0	594	594
5	591	598
15	566	609
25	545	556
35	344	394
45	184	205
55	74	83
65	32	28
75	0	0
85	0	0
90	0	0

Average Luminance

Deg.	CD/SQ M 0°	90°
45	14115	17242
55	3042	3791
65	4028	4195
75	0	0
85	0	0

Cone of Light

Distance to Illuminated Plane	Initial Nadir Footcandles	Beam Diameter
5'0"	20	6'0"
6'0"	14	8'0"
8'0"	8	9'0"
10'0"	6	12'0"
12'0"	4	14'0"
14'0"	3	17'0"

Beam diameter is to 50% of maximum footcandles, rounded to the nearest half-foot.

Footcandle values are initial, apply appropriate light loss factors where necessary.

Lamp Multiplier
26W PLT=.[illegible]

Reflector Multiplier
Haze=.95
Straw=.[illegible]
Wheat=.[illegible]

EM Multiplier (In emergency mode)
EM=.27

Zonal Lumen Summary

Zone	Lumens	%Lamp	%Luminaire
0-30	468	19.5	49.0
0-40	699	29.1	73.2
0-60	917	38.2	96.1
0-90	955	39.8	100.0
90-180	0	0.0	0.0
0-180	955	39.8	100.0

Coefficient of Utilization

rc	80%				70%			50%		30%		10%		0%
rw	70	50	30	10	50	30	10	50	10	50	10	50	10	0
RCR														
0	47	47	47	47	46	46	46	44	44	42	42	41	41	40
1	45	44	43	42	43	42	41	41	40	40	39	37	37	40
2	43	40	39	37	41	38	37	38	36	37	35	38	35	34
3	40	37	35	34	37	35	33	36	33	35	32	34	32	31
4	38	35	32	31	34	32	30	33	30	32	30	32	29	29
5	36	32	29	28	33	29	27	31	27	30	27	30	27	26
6	33	30	27	25	29	27	25	28	25	28	25	28	24	24
7	31	27	25	23	27	24	23	26	23	26	22	25	22	22
8	29	25	23	21	25	22	21	25	21	24	21	24	21	20
9	26	23	21	19	23	21	19	23	19	22	19	22	19	18
10	26	22	19	17	21	19	17	21	17	21	17	21	17	18

rc=Ceiling reflectance, rw=Wall reflectance, RCR=Room cavity ratio
CU Data Based on 20% Effective Floor Cavity Reflectance.

Cooper Lighting
www.cooperlighting.com

Specifications and Dimensions subject to change without notice.
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PSU

DC-4-d1

THE CHAMELEON

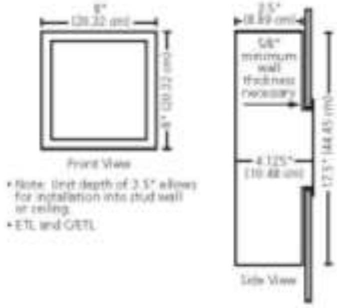
To enhance its unobtrusive design and compact size, the Chameleon can be customized with wallpaper, fabric, or laminate in the field. And there's no minimum quantity required for custom manufacturing, including crafting all visible parts in custom metals such as bronze, pewter, or brushed aluminum, or applying custom paint colors. Contact your local Concealite representative for more information.

Product Specification

The emergency lighting unit shall be Concealite Chameleon and will conform to UL Standard #924 and be installed in accordance to Article 700 of the National Electrical Code. The unit will be stored in a retracted position during normal power conditions and upon the loss of utility power, will be deployed into the open position and the lamps energized. Restoration of utility power will cause the unit to retract to the stored position and the lamps extinguish. The unit shall be constructed of cold rolled steel. Motor shall be a 12 volt sealed permanent magnet type with a 30 year service life. The electronics shall be a solid state design. Lamps shall be MR-16 with GU-10 Bi-Pin twist lock base. The unit shall be available in 12, 24, 120 and 277 volt configurations.

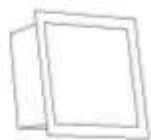
Limited Warranty

All Concealite equipment is guaranteed against defects in materials and workmanship by the manufacturer for a period of three years from date of shipment under normal operations and proper use. Correction of all defects shall be by replacement or repair (at our option) and shall constitute fulfillment of all manufacturer's obligations. Batteries provided as part of unit's equipment and carry a three year full warranty with an additional pro-rated guarantee.



- Note: Unit depth of 3.5" allows for installation into stud wall or ceiling.
- ETL and C/ETL

Required rough opening in wall or ceiling is:
7.25" (18.42 cm) high
6.75" (17.15 cm) wide



Ordering Information

FS REM 20 12V Option(s)

Series
FS - (Flush)

Remote Lighting Unit
REM - Remotely Powered by a Central Battery System or 120 or 277 volts VAC

Lamps
12 - 12 Watt Quartz Halogen Lamps
20 - 20 Watt Quartz Halogen Lamps
35 - 35 Watt Quartz Halogen Lamps
50 - 50 Watt Quartz Halogen Lamps
75 - 75 Watt Quartz Halogen Lamps

Options
PT - Plaster Trim
SM - Surface Mount Enclosure
CF - Custom Finish (Specify color)
TBAR - T-Bar Mounting Kit
RETRO - Retro Fit Back Box
See Technical Section for Details
CBLK - C-Block Back Box

Voltage
12 VDC
24 VDC
120 VAC
277 VAC

Please refer to the remote wiring section in the optional technical data section of the catalog for the number of conductors needed to control remote fixtures.

Note: These specifications are subject to change.

CONCEALITE
LIFE SAFETY PRODUCTS

A Division of Gow Industries
202 Elk Street
P.O. Box 160
Elkton, SD 57026
Phone: (605)542-4444
Fax: (605)542-3333
http://www.concealite.com
e-mail: info@concealite.com

1003-1202

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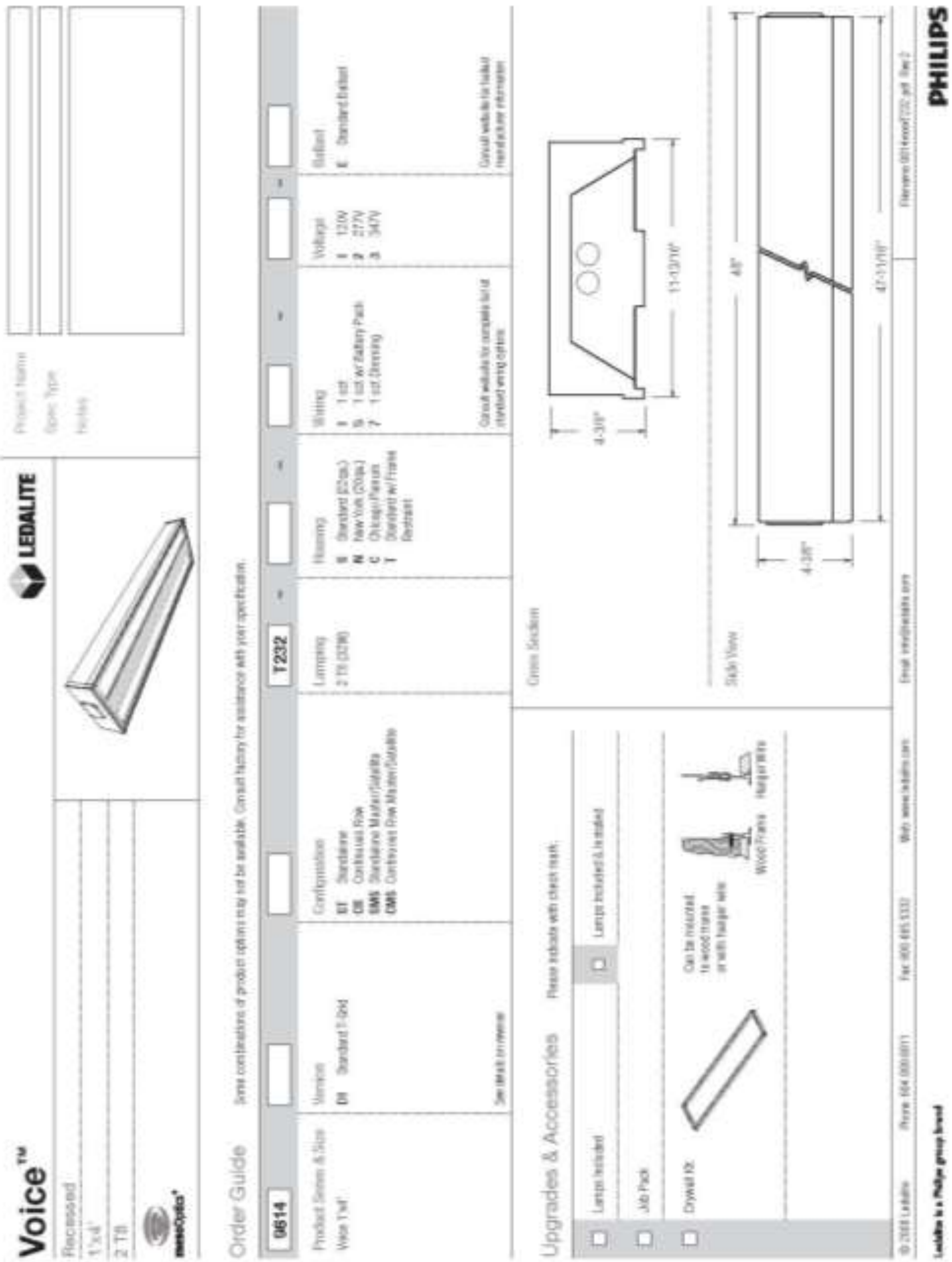
PSU
EL-5



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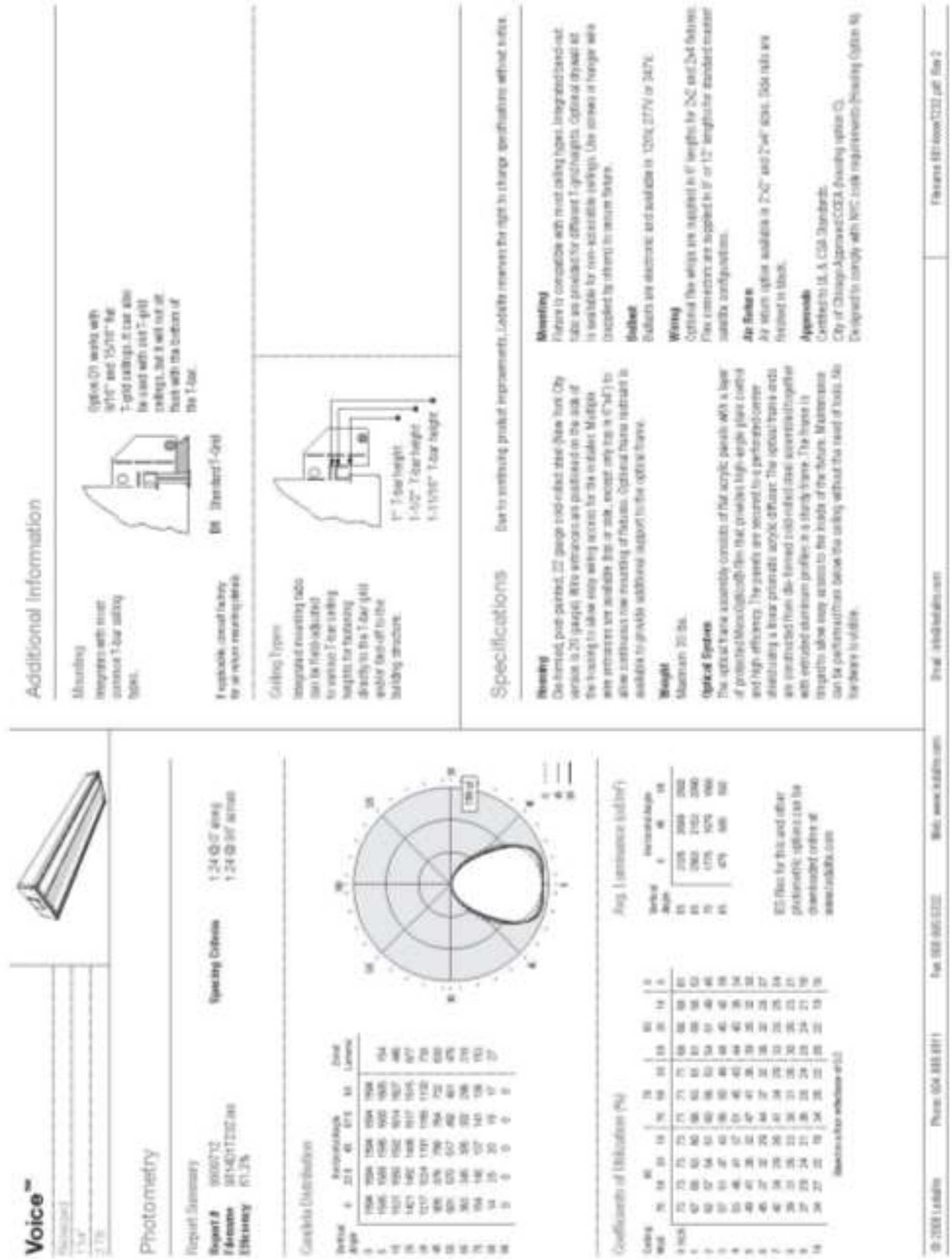
PSU

NF-1



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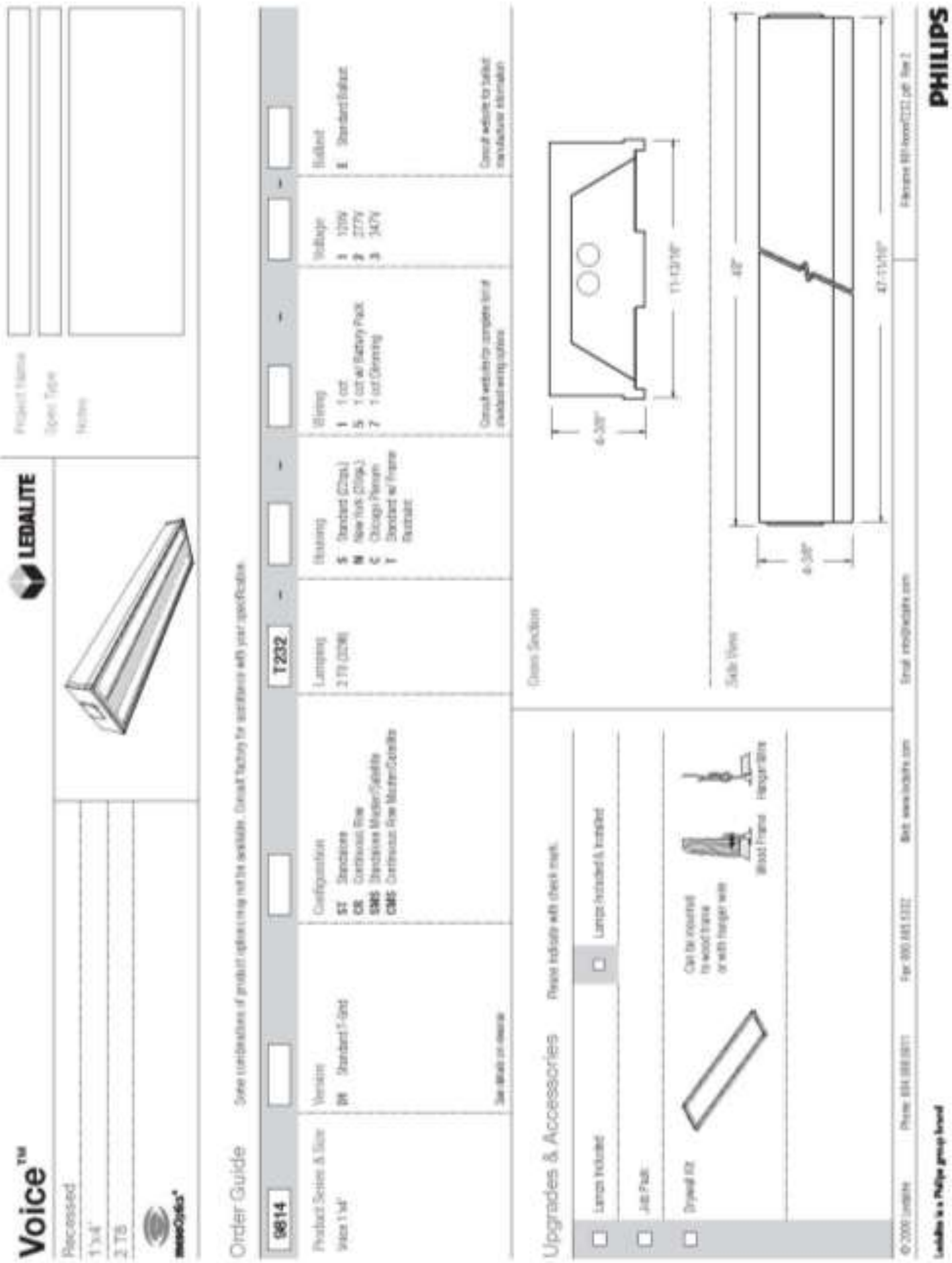
PSU

NF-1



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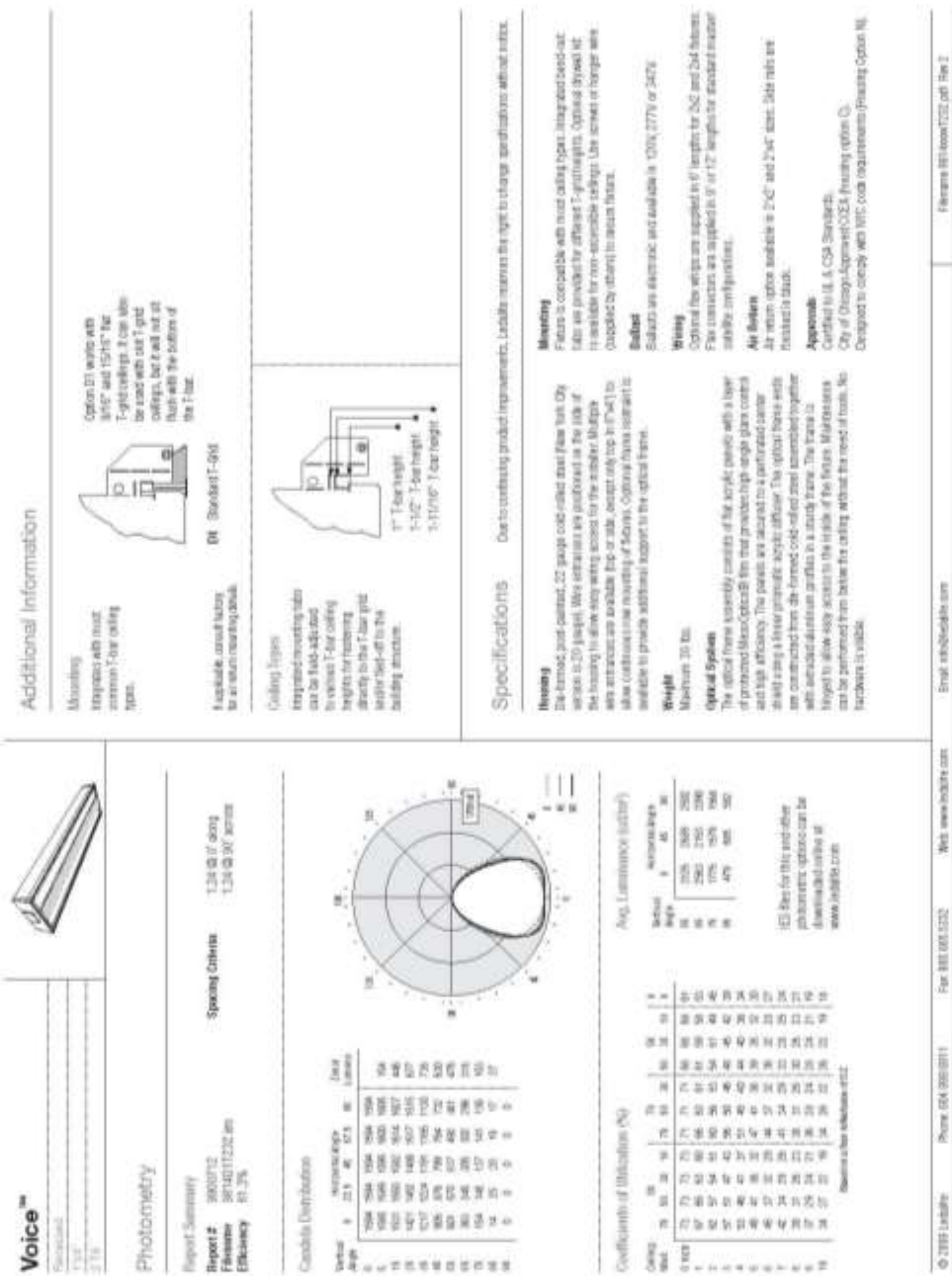
PSU

NF-1B-d1



bpi

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PSU

NF-1B-d1

M100 Recessed Linear Fluorescent Flanged Extrusion - STAGGERED LAMPS

se'lux

Project: ____________ Type: ________ Qty: ________

Fixture Series - Lamp Type - Shielding - Mounting - Nominal Length - Finish - Voltage

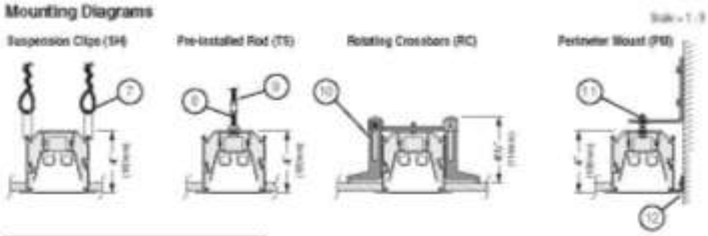
Options (refer to separate data sheets for ordering codes and details)

Fixture Series	Lamp Type	Shielding	Mounting	Nominal Length	Finish	Voltage	Options
M1R1S M100 Recessed Continuous Flange (Flanged Extrusion Flanged Endcaps) Staggered Lamps **M1R2S** M100 Recessed Flush End (Flanged Extrusion Flangeless Endcaps) Staggered Lamps	**1T5** F28T5 **1T5HO** F54T5HO **2T5** (2)F28/T5 2T8	**SD** Satine Lens **OD** Extra Diffuse Lens	**SH** Suspension Clips **TS** 1" Stud (factory installed) **RC** Rotating Crossbars **PM** Perimeter Mount	**008** 8 foot **012** 12 foot For actual lengths see following page. For other lengths, configure from listable nominal length rounded to the next highest foot. Factory will supply layout drawings. Individual fixtures cannot be field joined.	**WH** White **BK** Black **SV** Silver **SP** Specify RAL#	120 277 347	**TB** Lengths to Fit 2' Grid T-Bar Ceiling System[1] **qty EM** Stand by Battery Pack[3] (prefix quantity, i.e. - 1EM) **FS** Single Fusing **DIM** Dimming[2] (specify system) **DIMA** Digital Addressable Dimming[2] **FW** Flex Whip (standard) **FW1** Flex Whip (dimming) **Track** Extra Standard[3] **DL** Suitable for Damp Locations **CCEA** Chicago Plenum **Downlights** (See MR16 spec sheets, pp. [illegible])

[1] Available with M1R1S only. [2] Must be low profile ballasts ([illegible]), consult factory for details. [3] Consult factory for details.

Mounting Diagrams

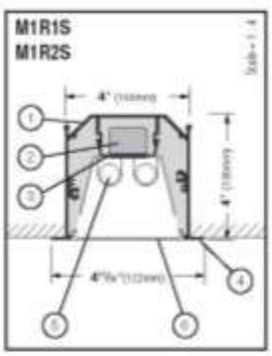
Scale = 1:3



Track

Track insert including track available for all configurations, consult factory for details.

M1R1S
M1R2S



1. Housing - Continuous, 6063-T5 extruded aluminum profile up to 16 feet long. Joined with Connector Plus Joining System for ease of installation and to ensure a uniform appearance.

2. Ballast - Electronic, high power factor, class "P", type "A" sound rating. Specify 120v, 277v, or 347v. Ballast is factory pre-wired with leads to one end of fixture. Consult factory for ballast options.

3. Gear Tray - Die formed gear tray with integral factory preset sliding covers to fit extrusion with light, with a matt white finish for even illumination. Geartray installs as complete electrical unit and is held in place with knurled dress nuts. It is fully accessible from below ceiling.

4. Flange - 1/2" (12mm) wide flange runs full lengths of both sides and is part of the main extruded body. Specify continuous flange (M1R1S) or flangeless endcaps (M1R2S).

5. Lamps - As noted (by others). Other lamp lengths or wattages available, consult factory.

6. Shielding - Choose between **OD** Extra Diffuse Lens and **SD** Satine Lens. See page 8 for more details.

7. Spring Steel Suspension Clips - Supplied two places, located nominally every 4 ft. Support wires supplied and installed by others.

8. Pre-installed 1" 1/4-20 Stud - Attached to fixture every nominal 4 feet.

9. Coupling and Threaded Rod to Structure - Supplied and installed by others.

10. Rotating Crossbar - For inaccessible ceilings, adjustable for ceiling thicknesses from 1/4" to 2". Support required nominally every 4'.

11. Steel Wall Bracket and 1/4-20 Rod - Supplied nominally every 4 ft. Fasteners to wall and wall anchors by others.

12. Aluminum Wallbracket - Secured to wall (fasteners and wall anchors by others) and runs entire length of fixture. Also supplied for width of fixtures when supplied with continuous flange. Allows for 1/8" gap between flange and wall to create shadow line allowing for unevenness of wall.

Interior Luminaire Finish - Standard interior colors are White (WH), Black (BK) and Silver (SV). RAL colors (SP) are available, please specify RAL#.

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FAX: (845) 691-6749
www.selux.com/usa
M1R1S-01 (v5.0)

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58

(2) T8 MODIFICATION

bpi
brandston partnership inc.
Lighting design
122 West 26th Street 5th floor
New York New York 10001
T. 212.924.4050 F. 212.691.5418

PSU

NF-5

PHOTOMETRICS

2P2GAX

2P2GAX-332S38I
Electronic Ballast
F32T8/35K lamps
2900 lumens
Spacing criterion: (II) 1.2 x mounting height, (⊥) 1.4 x mounting height
Efficiency = 72.7%
Test Report: 2P2GX332S38I.IES
LER = FP-63
Yearly Cost of 1000 lumens, 3000 hrs at .08 KWH = $3.81

Coefficients of Utilization

Effective floor cavity reflectance 20%

pc	80%				70%				50%			30%			10%			0%
pw	70	50	30	10	70	50	30	10	50	30	10	50	30	10	50	30	10	0
RCR																		
0	87	87	87	87	85	85	85	85	81	81	81	77	77	77	74	74	74	73
1	81	78	76	74	79	77	75	73	74	72	71	71	70	68	69	67	66	65
2	75	71	67	64	74	70	66	63	67	64	62	65	62	60	63	61	58	58
3	70	64	59	55	68	63	58	55	61	57	54	59	56	53	57	54	52	51
4	65	57	52	48	63	56	51	48	55	50	47	53	49	46	52	48	46	44
5	59	51	45	41	58	50	45	41	49	44	41	48	43	40	46	43	40	38
6	55	46	40	36	54	45	40	36	44	39	36	43	38	35	42	38	35	34
7	50	41	35	31	49	41	35	31	40	35	31	38	34	31	38	34	31	29
8	46	37	31	27	45	36	31	27	36	30	27	35	30	27	34	30	26	25
9	42	33	27	23	41	33	27	23	32	27	23	31	26	23	30	26	23	21
10	39	30	24	20	38	29	24	20	29	24	20	28	23	20	27	23	20	19

Zonal Lumen Summary

Zone	Lumens	%Lamp	%Fixture
0-30	1903	22.7	31.1
0-40	3291	38.2	53.9
0-60	5657	67.3	92.6
0-90	6110	72.7	100.0
0-180	6110	72.7	100

Typical VCP Percentages

Room Size (ft.)	Height Along 8.5'	Height Along 10.0'	Height Across 8.5'	Height Across 10.0'
20 x 20	75	71	74	70
30 x 30	69	77	65	80
30 x 60	65	81	67	84
60 x 30	63	81	67	84
60 x 60	68	84	69	87

Candela

Angle	Along II	45°	Across ⊥
0	2309	2309	2309
5	2300	2306	2316
10	2283	2301	2343
15	2253	2337	2378
20	2135	2348	2366
25	2031	2329	2444
30	1932	2302	2600
35	1794	2172	2750
40	1644	2158	2517
45	1473	2013	1968
50	1274	1669	1340
55	1038	1164	889
60	765	808	521
65	441	339	320
70	182	196	182
75	97	41	25
80	33	14	11
85	7	5	4
90	0	0	0

ORDERING INFORMATION

Sample Number: 2P2GAX-332S38-120V-EB81-U

Heat Removal
HR: Heat Removal[1]
HRDO: Heat Removal Damper Open
HRDC: Heat Removal Damper Closed

Width
2: 2' Width

Series
P2: Parabo II

Trim Type [3]
G: Grid Lay-In - Standard
T: Concealed T-Slot Grid
F: Flange Trim
MZ: Modular Trim

Air Supply
AX: Air Supply Floating Louver
X: Black Side Floating Louver - Non Air Supply
AVX: Air Supply Floating Louver w/Directional Air Vane

Number of Lamps *
3 Lamps (Not Included)

Wattage
32: 32W T8 (48")

Louver Color
S: Silver
G: Gold
W: White

Cell Configuration
38: 3 Rows of 8, 24 Cell (2'x4')

Louver Finish
H: Semi Specular/Haze (Gold Only)
I: Semi Specular/Haze (Low Iridescent) Standard
MI: Specular/Mirrored (Low Iridescent)
P: Painted

Voltage *
120V: 120 Volt
277V: 277 Volt
347V: 347 Volt
UNV: Universal Voltage[5] 120-277

Options
GL: Single Element Fuse
GM: Double Element Fuse
WTR: White Reveal
Lamps: Lamps Installed
Flex: Flex Installed
Emergency: EM Installed

Ballast Type *
EB: Electronic Ballast
ER: Generic Rapid Start
DLS: Dimming Ballast

Lamp Size
8: T8

Number of Ballasts
1: 1 Ballast
2: 2 Ballast
3: 3 Ballast

Options
/PLUS: Higher Ballast Factor(1.18)
RLS: Rotor Lock Socket (T8 Lamp only)
SEP: Advance Suppressor
2BC: 2 Ballast Covers
FR: Fire Rated Label
20GA/REP: 20 Gauge Housing w/Riveted End Plate
MEP: Modified End Plate
PAF: Painted After Fabrication

Packaging
U: Unit Pack
PAL: Palletized Uncartoned Fixtures
PALC: Palletized Fixtures in Cartons

Notes: 1 Integral End Plate Grid Lock feature not available in Heat Removal.
2 [illegible]
3 An EQ Grid Clip is recommended for all 9/16" ceiling systems.
4 Standard off center ballast on 3 lamp fixtures.
5 Products also available in non US voltage and frequencies for international markets.
6 Not Available when specifying emergencies, voltage must be specific.

ACCESSORIES

EQ - T-BAR Safety Earthquake Clips [3]

SHIPPING INFORMATION

Catalog No.	Wt.
2P2GAX-332S38	42 LBS.

COOPER Lighting
www.cooperlighting.com

Specifications and Dimensions subject to change without notice.
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In-Cove II

LEDALITE

Cove
Indirect
2 T8

Project Name
Spec Type
Notes

Order Guide

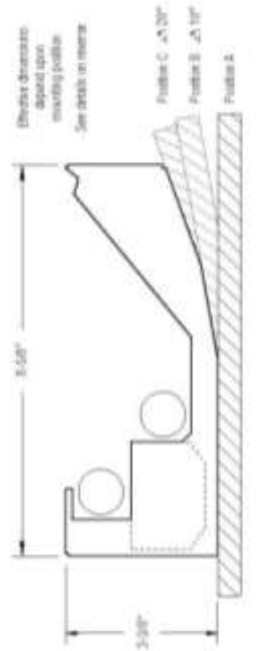
Some combinations of product options may not be available. Consult factory for assistance with your specification.

Product Series & Type	Lamping	Lower Option	Upper Option	Run Length	Wiring	Voltage	Ballast	Color & Finish
3808	T02							
In-Cove II Indirect	2 T8	E Solid Housing	N None	Enter the total run length in feet	1 1 ckt 2 2 ckt 3 1 ckt w/ Emergency ckt 4 2 ckt w/ Emergency ckt 5 1 ckt w/ Battery Pack 6 2 ckt w/ Battery Pack 7 1 ckt Dimming	1 120V 2 277V 3 347V	E Standard Ballast	W High Reflectance White
				See details on reverse	Consult website for complete list of standard wiring options		Consult website for ballast manufacturer information	

Upgrades & Accessories

Please indicate with check mark.

☐ Lamps Included
☐ Lamps Included and Installed



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PSU

NF-10

In-Cove II

Cove
Indirect
2 T8

Photometry Optics BN

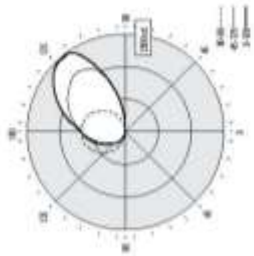
Report Summary

Report # 2100279
Filename 3800T82EN.ies
Efficiency 72.7%

Peak Candela Value* 1986 @ 125°
Peak to Zenith Ratio* 2.2 : 1
*Between 90-180° vertical angle

Candela Distribution

Vertical Angle	0	22.5	45	67.5	90	Zonal Lumens
0	0	0	0	0	0	
5	0	0	0	0	0	0
15	0	0	0	0	0	0
25	0	0	0	0	0	0
35	0	0	0	0	0	0
45	0	0	0	0	0	0
55	0	0	0	0	0	0
65	0	0	0	0	0	0
75	0	0	0	0	0	0
85	0	0	0	0	0	0
90	0	0	0	0	0	
95	204	300	36	11	6	176
105	900	477	176	64	86	477
115	1510	1094	330	140	153	700
125	1473	1534	479	271	267	774
135	1961	1532	610	365	333	710
145	1736	1423	725	484	425	592
155	1547	1260	826	612	552	435
165	1270	1126	870	736	663	264
175	984	984	932	927	937	39
180	904	904	904	904	904	



Coefficients of Utilization (%)

Ceiling	80				70			50			0
Wall	70	50	30	10	70	50	30	50	30	10	0
0 RCR	66	66	66	66	59	59	59	40	40	40	0
1	61	60	57	55	52	51	49	35	34	32	0
2	57	52	48	46	48	46	41	30	28	27	0
3	52	48	41	37	44	39	35	27	24	22	0
4	47	40	35	31	40	34	30	23	21	19	0
5	43	35	30	26	37	30	26	21	18	16	0
6	39	31	26	22	33	27	23	19	16	13	0
7	36	28	23	19	31	24	20	17	14	12	0
8	33	25	20	17	28	22	17	16	12	10	0
9	31	23	18	14	26	20	15	13	11	9	0
10	29	21	16	13	24	19	14	12	9	8	0

Based on a floor reflectance of 0.2

Avg. Luminance (cd/m²)

Surface Angle	0	45	90
55	0	0	0
65	0	0	0
75	0	0	0
85	0	0	0

IES files for this and other photometric options can be downloaded online at www.ledalite.com

Additional Information

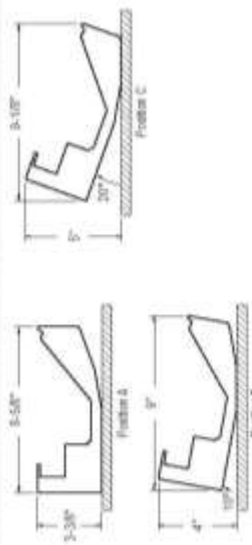
Modules

Nominal module length shown in right.

Module	Nominal Length
2H	2'0"
3H	3'0"
4H	4'0"
6H	6'0"
8H	8'0"

Mounting Positions

Fixtures can be mounted in multiple positions to adjust for specific site and lighting requirements.



Specifications

Due to continuing product improvements, Ledalite reserves the right to change specifications without notice.

Housing
Die-formed 20 gauge cold-rolled steel painted white.

Weight
3.0 lb/ft.

Optical System
Constructed of highly specular Miro 4®aluminum* and highly reflective 20 gauge steel to produce an asymmetric distribution.
* Note: 2T8 constructed of highly specular aluminum.

Mounting
Fixtures can be screwed down in multiple positions and orientations to enable precise coordination of optical distributions.

Electrical
Factory pre-wired to section ends with quick-wire connectors.

Ballast
Electronic.

Approvals
Certified to UL & CSA standards.

 Phone: 604 888 6811 Fax: 888 665 5332 Web: www.ledalite.com Email: info@ledalite.com Filename 3800T82EN.pdf Rev 1

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Additional Daysim Information

South Façade

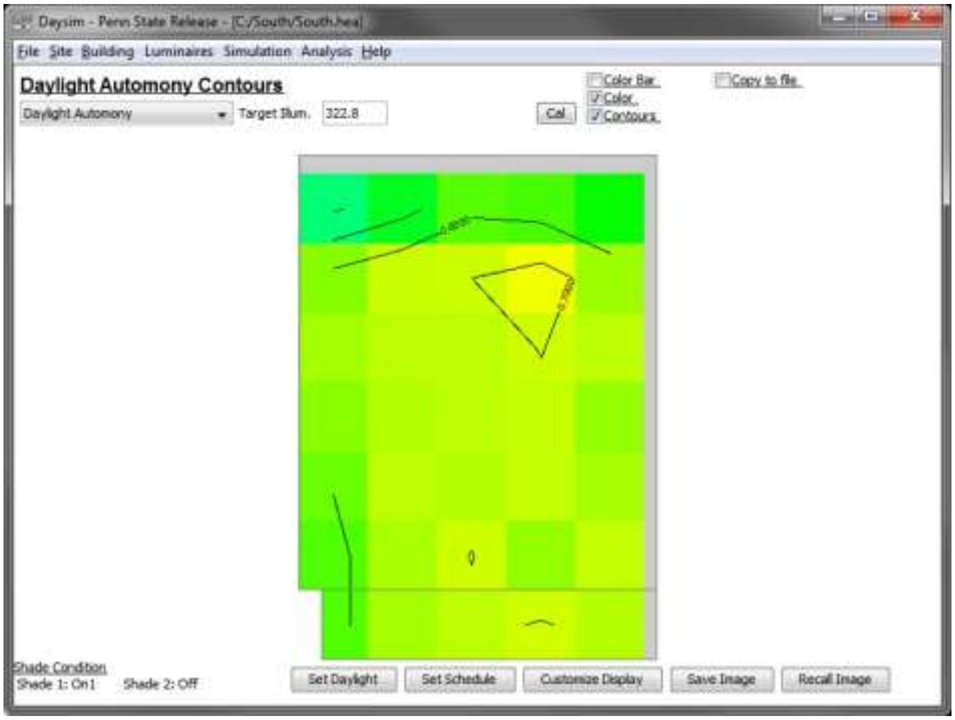

Figure C: 30fc Daylight Autonomy – South Façade

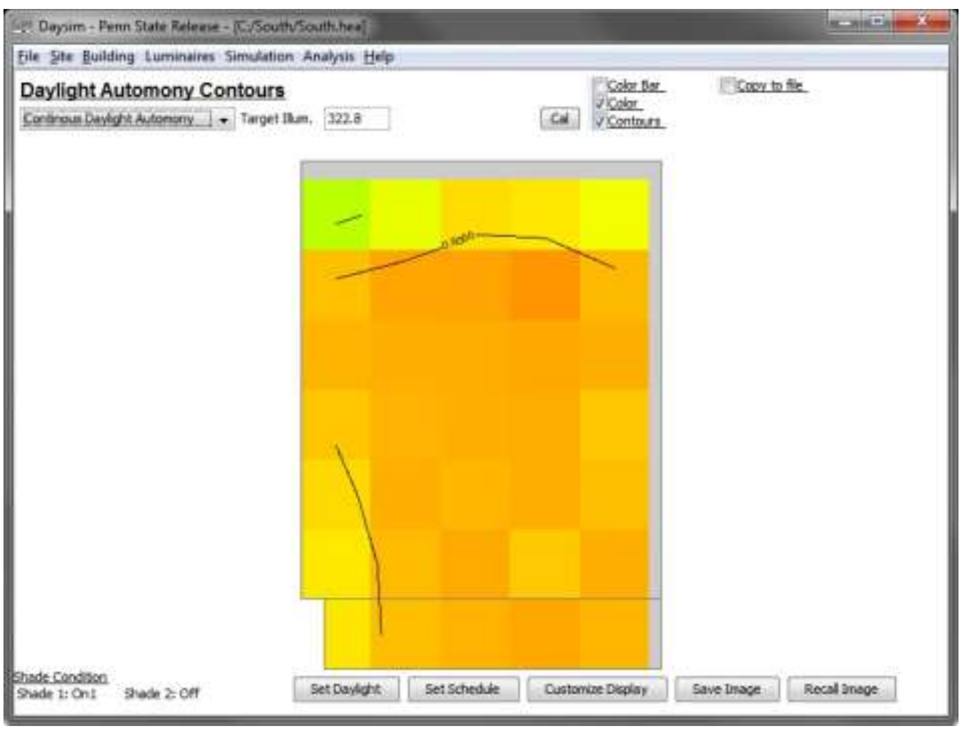

Figure D: 30fc Continuous Daylight Autonomy – South Façade

East Façade

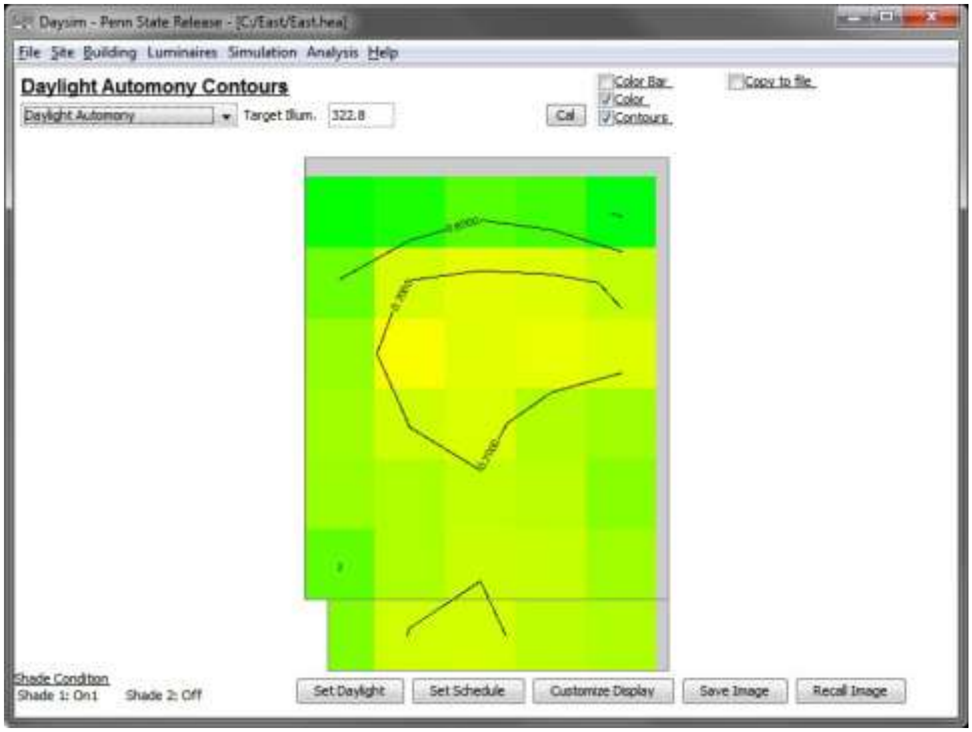

Figure C: 30fc Daylight Autonomy – East Façade

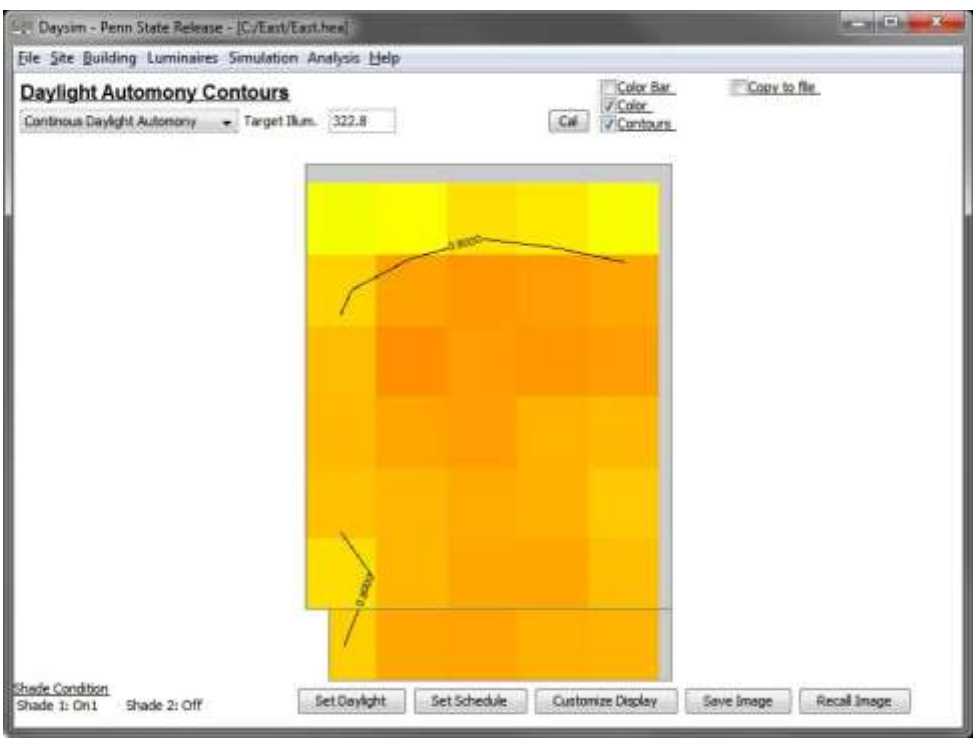

Figure E: 30fc Continuous Daylight Autonomy – East Façade

West Façade

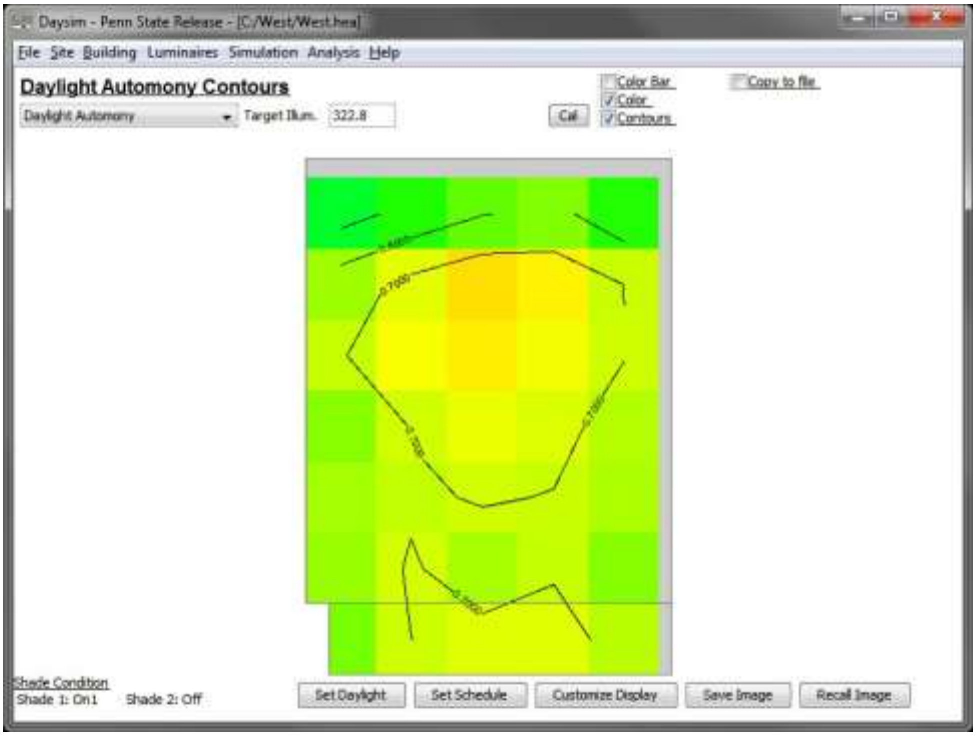

Figure F: 30fc Daylight Autonomy – West Façade

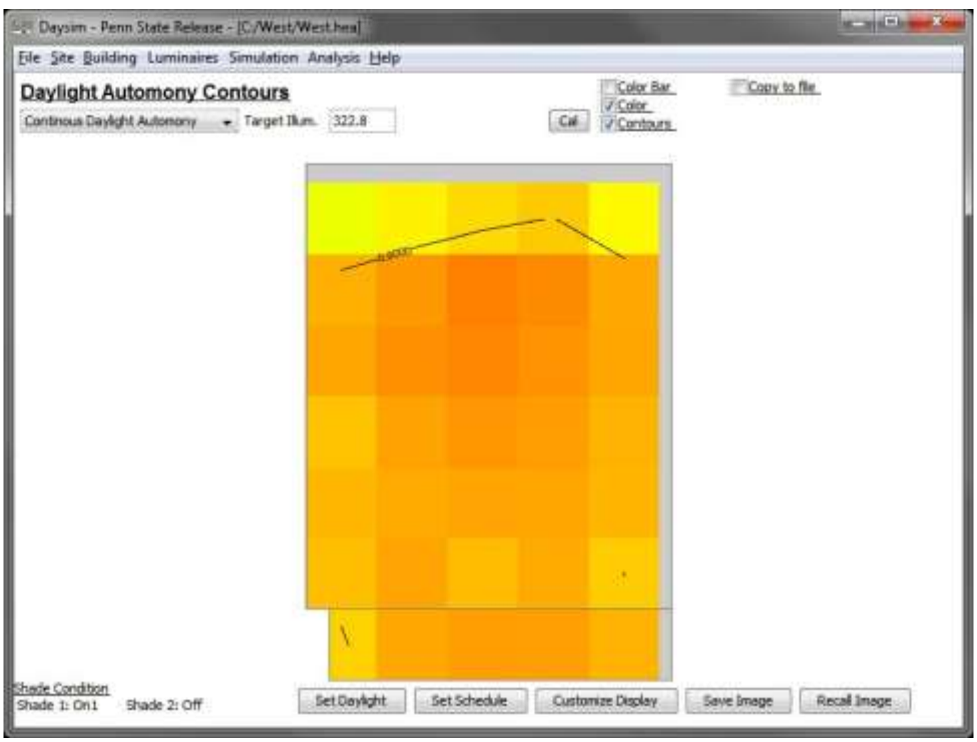

Figure G: 30fc Continuous Daylight Autonomy – West Façade